

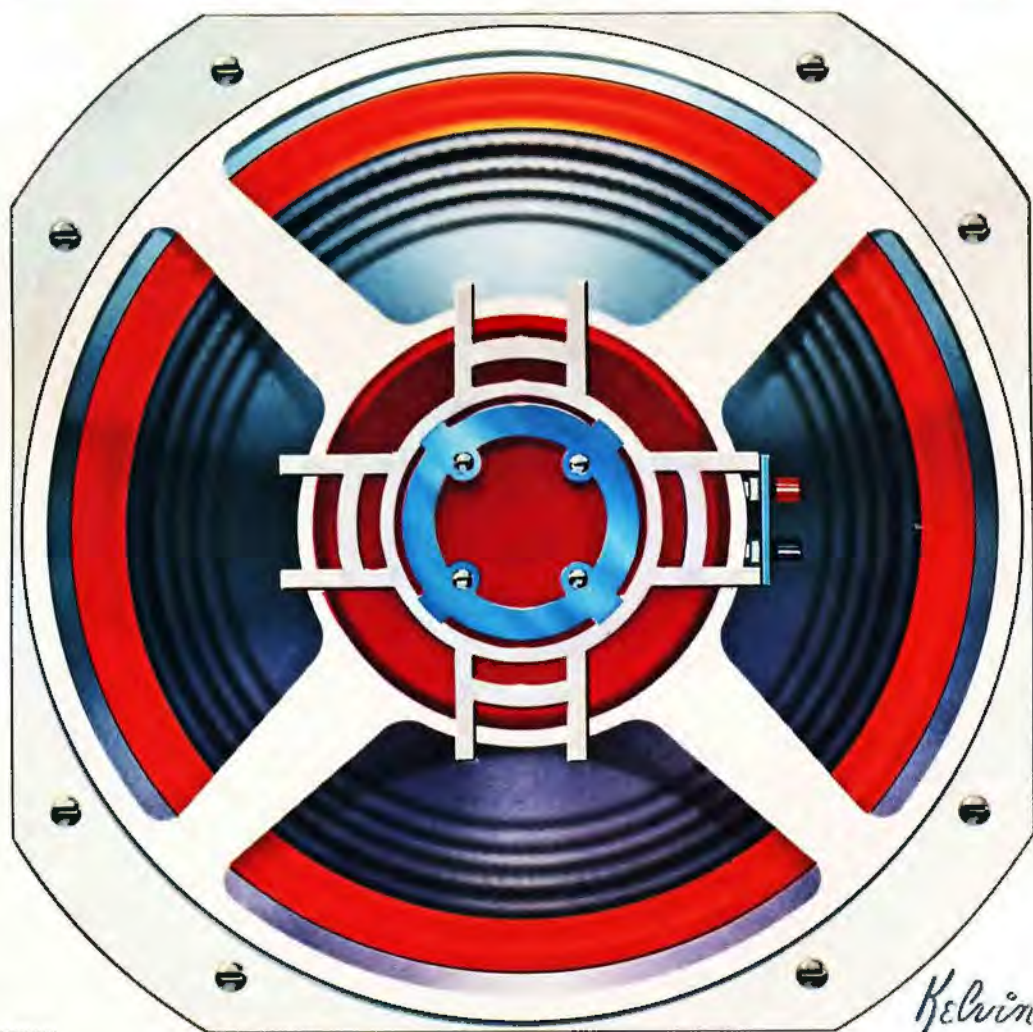
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JUNE 1978/\$1

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Special Focus On Hi-Fi Speaker Systems
MODEL-BY-MODEL COMPARISONS & HOW-TO-AUDITION GUIDE



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To install the unit, you simply turn off the fuse for that outlet, remove your present light switch, and replace it with the new one. There's no soldering required—just twist on a few wire nuts and you're finished.

The switch can be overridden and used just like a regular light switch by pressing a button to turn on the light. One of the nice features of the system is its appearance—that of a space-age switching system—sure to be a conver-

sation piece in any room.

The only drawback is that in a power failure, the lights go on and stay on after the power outage. But this could also be considered an advantage as it would warn your neighbors to stop by and check out your home.

The Hutech security switch costs only **\$39.95** plus \$2.50 for postage and handling per order. It is well worth a test. If you like the switch, order some for your entire home. Even if they just replace your existing switches, you'll have the only home on the block with a digital watch in each one of your light switches.

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POPULAR ELECTRONICS, June 1978, Volume 13, Number 6. Published monthly at One Park Avenue, New York, NY 10016. One year subscription rate for U.S. and Possessions, \$12.00; Canada, \$15.00; all other countries, \$17.00 (cash orders only, payable in U.S. currency). Second Class postage paid at New York, NY and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada, and for payment of postage in cash.

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Forms 3579 and all subscription correspondence: POPULAR ELECTRONICS, Circulation Dept., P.O. Box 2774, Boulder, CO 80302. Please allow at least eight weeks for change of address. Include your old address, enclosing, if possible, an address label from a recent issue.

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Feature Articles

- 30 **HOW NECESSARY IS SELECTABLE I-F BANDWIDTH IN AN FM TUNER?** / Julian Hirsch
- 48 **MICROPROCESSOR MICROCOURSE** / Forrest M. Mims
Part 4: PIP-2—An ultra-simple educational microprocessor.
- 56 **FOCUS ON SPEAKER SYSTEMS** / Ivan Berger
I. UNDERSTANDING THE SPECIFICATIONS.
II. UNDERSTANDING WHAT YOU HEAR.
- 63 **SPEAKER SPECIFICATION GUIDE**
- 88 **EXPERIMENTS WITH PROGRAMMABLE LOGIC ARRAYS** / Karl Lunt
Useful logic circuit has many applications in digital circuits.

Construction Articles

- 41 **PROTECT YOUR AIR CONDITIONER WITH A "COMPRESSOR GUARD"** / Richard B. Fermoye
Prevents compressor damage due to power failures or brownouts.
- 44 **ADD FUZZ TO YOUR ELECTRIC GUITAR OR BASS** / James Barbarello
Solid-state fuzz box for interesting sound effects.
- 46 **BUILD A LOW-COST SWR TESTER** / Cass Lewart
Uses Wheatstone bridge sensing circuit and lamp indicator.

Columns

- 26 **STEREO SCENE** / Ralph Hodges
For the Record—II.
- 92 **SOLID STATE** / Lou Garner
Motor Control Circuits.
- 98 **EXPERIMENTER'S CORNER** / Forrest M. Mims
The Voltage Multiplier.
- 106 **AMATEUR RADIO** / Karl T. Thurber, Jr.
Getting It Together as a Novice
- 110 **COMPUTER BITS** / Leslie Solomon
Computers to Aid the Handicapped.

Julian Hirsch Audio Reports

- 32 **NIKKO GAMMA I STEREO FM TUNER**
- 34 **FISHER MODEL CR-4025 CASSETTE DECK**
- 37 **SHURE MODEL V15 TYPE IV STEREO PHONO CARTRIDGE**

Electronic Product Test Report

- 100 **TRAM MODEL D62 AM/SSB MOBILE CB TRANSCEIVER**

Departments

- 4 **EDITORIAL** / Art Salsberg
The Perfect Speaker Quest.
- 12 **LETTERS**
- 16 **NEW PRODUCTS**
- 24 **NEW LITERATURE**
- 113 **SOFTWARE SOURCES**
- 114 **ELECTRONICS LIBRARY**
- 132 **OPERATION ASSIST**

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Editorial and Executive Offices
One Park Avenue New York, New York 10016
212-725-3500

Joseph E. Mesics (725-3568)
John J. Corton (725-3578)

Midwestern Office

The Patis Group, 4761 West Touhy Ave.
Lincolnwood, Illinois 60466 312-679-1100
Thomas Hockney, Michael Neri, Gerald E. Wolfe
Western Office
9025 Wilshire Boulevard, Beverly Hills, CA 90211
213-273-8050, BRadshaw 2-1161
Western Advertising Manager Bud Dean

Japan: James Yagi
Ori Palace Aoyama, 6-25, Minami Aoyama
6 Chome, Minato-Ku, Tokyo 407-1930/6821
582-2851



Editorial

THE PERFECT SPEAKER QUEST

Music has an influence on high-fidelity equipment. As an example, an unsung musical revolution of World War II days that spawned much of today's musical style advanced the need for better audio systems. This then-new art form was also my initial motivation for searching out better and better speaker system—a search that has not yet ended.

The music had its start at the Minton Playhouse, nor far from New York's Apollo Theatre. Its pioneer musicians were the cream of orchestral jazz sidemen. The style was the type of progressive jazz known as "Bebop," with a tradition-shattering rhythm-section technique that extends to both jazz and rock today.

When I first heard Bop on records and radio broadcasts, I simply couldn't comprehend it. It sounded discordant, true, but so did Beethoven's music when it was introduced. Worse, though, was the high level of distressing record-surface noise I heard. It wasn't until I heard it performed "live" that its true sound was revealed.

I concluded that my speaker (those were mono days, remember) was the cause of the distressing noise I heard at home, attributing this to unsatisfactory high-frequency reproduction, among other deficiencies. Here's why:

In Bop, the drummer's role became much more important and demanding. While a "swing" drummer such as Chick Webb or Gene Krupa used the bass pedal to keep time, accompanied by cymbal crashes, Bebop drummers—Kenny Clarke, Max Roach, et al—abandoned this style. They used, as do many modern drummers, the top cymbal as their "main" instrument for both 4/4 fundamentals and tonal dynamics. Thus, a continual, shimmering cymbal sound underlined the music. This freed the drummer's left hand and both legs for adding a variety of accents: a top-hat cymbal's "cha-cha" sound, a bass drum's abrupt thump a snare's pistol-like sound, a tom-tom, etc.

So, while most audiophiles of the day were terribly concerned about achieving deeper speaker bass, I also sought better treble and transient response. I needed this improvement to hear the cymbal's persistent sound, without which I couldn't assemble the musical puzzle.

This was no easy task. After all, a cymbal's frequency response extends to 16 kHz, a bass drum goes down to about 30 Hz, with some 25 watts acoustic power in real life. Add the string bass (which no longer simply followed a drum pedal accent) ranging from about 41 Hz to 8 kHz with overtones, and a piano stretching from 27½ Hz to almost 9 MHz with overtones. Top them off with a trumpet and a saxophone, each producing powerful mid-frequency fundamentals and high-frequency harmonics extending to 10 kHz, as spearheaded by Dizzy Gillespie and Charlie Parker, and the complex music elements of a modern jazz group were not easy to reproduce.

Furthermore, to capture the essence of the music, all the instrumental nuances had to be reproduced. This meant good transient response was necessary. Aside from overcoming one-note bass and dull-treble problems, the instrument's true color was at stake. (An instrument's higher overtones, which determine timbre, die out quickly.) Interestingly, one of the reasons for the difficulty in faithfully reproducing piano music is its "attack." Play a piano softly, for example, and many overtones are subdued. But strike piano keys hard and the amplitude of a host of momentary overtones might reach 50% of the fundamentals, imparting a different sound character. If a speaker system distorts these harmonics, then the piano's true sound won't be reproduced.

My quest for better speaker systems led me to a few basic texts, mainly authored by Abraham Cohen, G.A. Briggs, Harry Olson, and James Moir. (Cohen and Briggs, both of whom made important contributions to speaker development and public education on the subject, died this year.) After extensive experimentation with different speaker designs in a variety of listening rooms for almost a dec-

(Continued on page 6)

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EDITORIAL (Continued from page 4)

ade, I gathered a large audience in a small hotel ballroom to participate in speaker listening tests. The speaker systems chosen were the same models evaluated that year by *Consumer Reports*. Check-lists of sound attributes for grading speakers identified only by number were given to participants. The audience consisted of recording engineers, musicians, hi-fi editors, audio dealers, audiophiles and a scattering of men and women who had no special experience in high-fidelity sound. Speakers were hidden behind an acoustically transparent curtain, while a variety of program material specially prepared on master tapes by Capitol Records was alternately played on each system. The results were most interesting: (1) Preference rankings were unlike those listed by *Consumer Reports*. (2) Except for a few systems that exhibited distinct deficiencies, it was not possible to make a logical analysis of listeners' preferences based on their speaker listening experience, audio knowledge or occupation. It was clear then as now that each person has his or her own sense of what sounds best.

Though modern jazz is not a majority art form among listeners, it served me well over the years as an ideal program source for evaluating my audio system. Now, however, much of its complex music roots are evident on more widely favored pop and rock music. So today's sonic challenge to speaker systems and other components is more apparent. Hi-fi equipment buyers, therefore, face many of the same judgement problems I did years ago.

Loss of hearing, for example, is an important determinant in choosing a speaker system. You cannot evaluate what you don't hear! For example, the hearing of a 35-year-old male can be expected to be down about 6 dB at only 4 kHz as compared to a male in his early 20's. At about 60 years, the loss is typically some 30 dB! To a 20-year-old, then, a 4-kHz sound appears eight times as loud as it would to an older chap. A woman, in contrast, experiences less high-frequency hearing loss; perhaps half of a man's as she ages. But she does have a somewhat greater hearing loss at low frequencies. So what you will prefer in terms of extended frequency response depends in part on your sex and your age.

You can fool yourself about your hearing acuity by listening to loudly played test-frequency records or signal generator audio outputs. This will compensate up to a point for the aging effect in hearing (presbycusis). Airtight headphones will perform similarly at lower-than-earthshaking volume by eliminating ambient noise, which in a typical living room is probably about 43 dB or so. I can hear to almost 15 kHz in the foregoing situations. But at low power output levels at about 20 feet from the speaker systems, I don't go much above 13 kHz. With music playing, my HF detection abilities are less keen, of course. I proved this to myself by progressively filtering highs until a change was noticed.

Judging bass-frequency output of speakers can be tricky, too. The human ear can fill in bass that isn't there. Also, you may hear lots of output at a low-bass frequency, but it might consist largely of high-distortion energy. I used an old mono LP, "Hi-fi & Mighty" on an RCA label, for this checkout purpose, especially its "Musetta's Waltz" track. It featured Allen Organ solos, with continual pedal music. I also played Brahms' "Symphony #1" (Otto Klemperer on Angel) for the pounding-drum intro. The liner notes observed that violins came in over the drum beats. In my early speaker models, however, the strings were *under* the drums in sound level. Better speakers later proved that the writer was correct!

I discovered in books and practice years ago that room dimensions, furnishings and speaker placement have a great deal to do with speaker performance quality, too. Few of us enjoy perfect room dimensions for audio (said to be a ratio of 1 x 1.27 x 1.62) or the ideal reverberation time (about 0.5 second for an average-size room and 0.7 second for a larger room, say, 20 feet long). And every new speaker placement sets up different sound vibration modes. A change from mid-wall to corner can add 6 dB to bass energy, for example, but aesthetics don't always permit using such a reduced angle of radiation to achieve a higher SPL.

Searching out the best-sounding speaker systems for one's ears is a delightful pastime, I've always felt. More important, it's worth the effort because it can contribute more than any other audio component toward accurate reproduction of recordings and FM broadcasts. This issue's focus on speaker systems will give you a running start toward this end.

Art Salsberg

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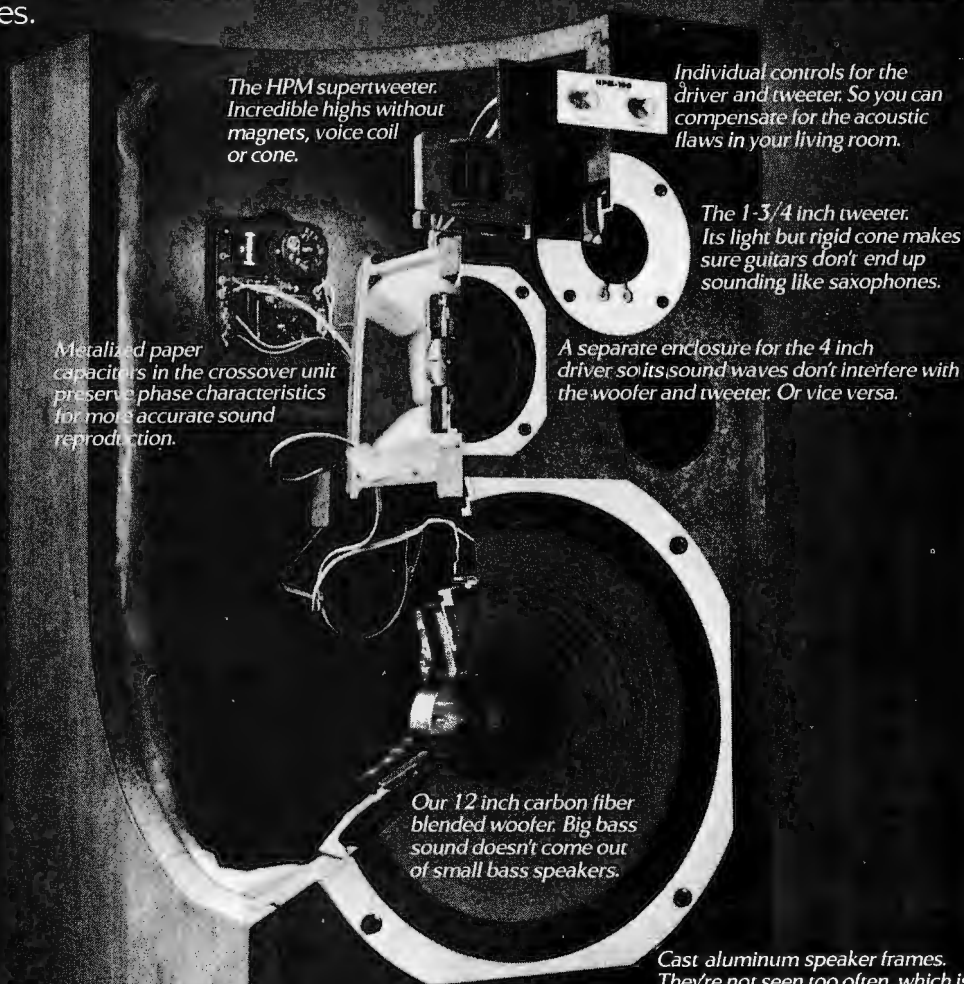
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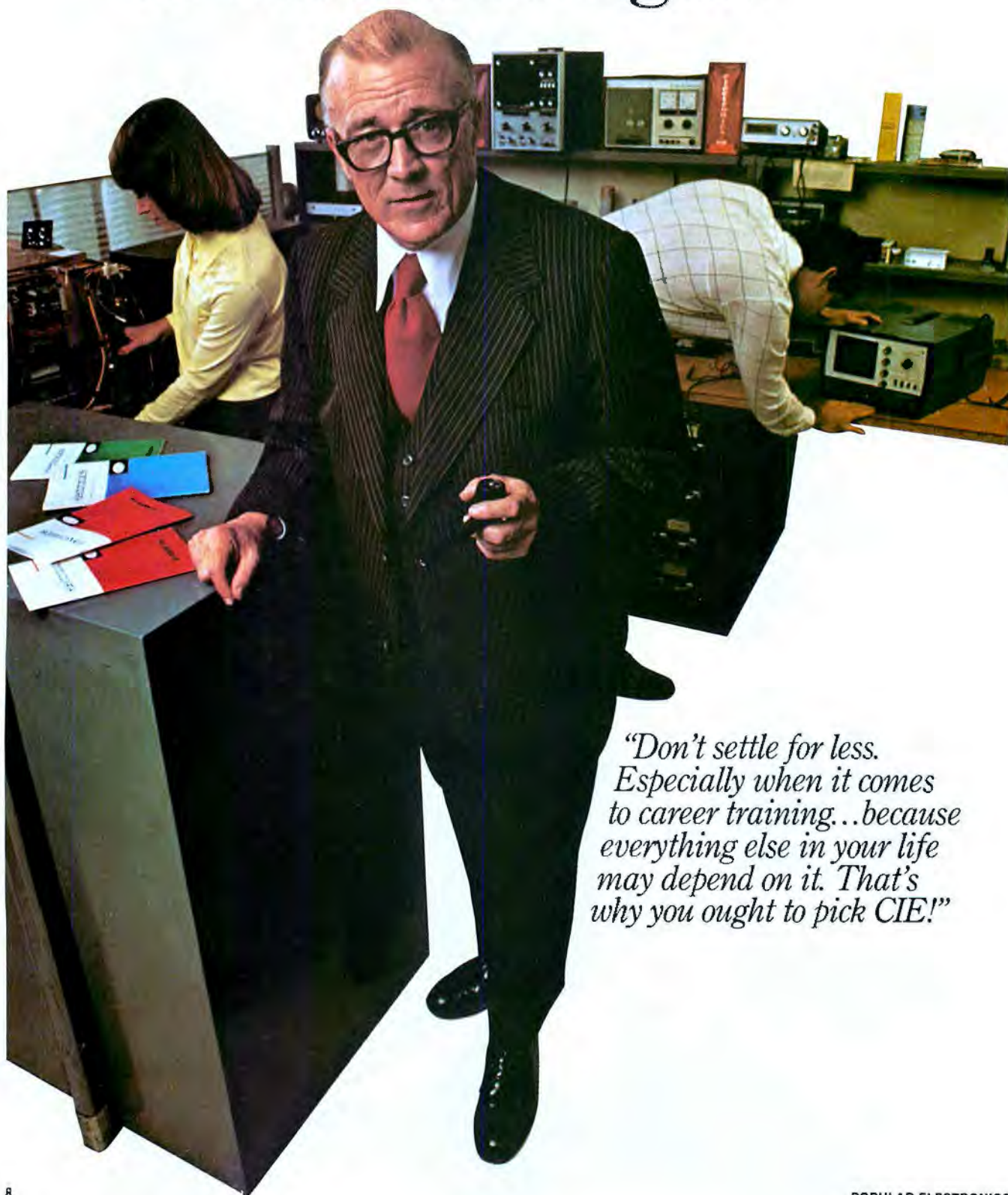
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A. Slip on new Audio-Technica Stereophones and

hear for yourself. If you want to find out how good the new Audio-Technica Stereophones really are, don't just compare them with other headphones. Put them up against the very finest *speaker* systems. But don't just listen to the equipment. Listen to the *music*. And be ready for a surprise!

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Letters

POORER BUT BETTER OFF

Thanks to POPULAR ELECTRONICS, I am now \$135 poorer. This may sound bad, but it is really good—at least I hope so. I have all of your articles on the Cosmac Elf microcomputer built around the 1802 μ P chip from RCA. They have aroused my interest so much that I have gone out and bought my own Elf microcomputer kit. —Robert J. Kastelic, South Milwaukee, WI.

THANKS FOR "EXPERIMENTER'S CORNER"

I would like to express my appreciation for the "Experimenter's Corner." This column is always lucid and interesting. I particularly enjoyed the December 1977 and January 1978 columns on read/write memories. Thanks to them, I now understand how data is placed into and retrieved from memory. I would like for author Forrest Mims to devote more space to digital and computer circuits. —Mark Jennings, Bellevue, WA.

TRANSMITTER THAT NEVER WAS

As I was leafing through the February 1978 issue of POPULAR ELECTRONICS, I noted that the Amateur Radio column made reference to the Heathkit Model HX-1675 amateur radio transmitter. The information for this article undoubtedly originated from someone here at Heath. Unfortunately, the Model HX-1675 was discontinued at the last minute and never offered for sale. —V. Virgil Bennett, Heath Co., Benton Harbor, MI.

UPDATING NBS SERVICES

We appreciate your help in keeping your readers abreast of changes in our standard time and frequency services. Here is some late information.

WWVL (which operated near 20 kHz until July 1972) no longer is in operation. WWVB (60 kHz), WWV and WWVH (2.5, 5, 10, and 15 MHz) are still on the air continuously.

Details of station operation, signal formats and other information about WWV, WWVB, and WWVH are included in *National Bureau of Standards Time & Frequency Dissemination Services*, a 60¢ booklet available as NBS Special Publication 432 from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. (SP 432 replaces SP 236.) —Collier N. Smith, NBS, Boulder, CO 80302.

Out of Tune

In "Expanding the Elf II" (March 1978), transistors Q2 and Q4, in Fig. 3, should be types 2N5354.

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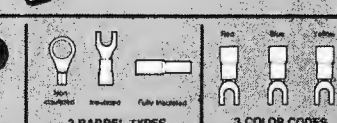
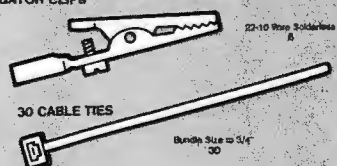
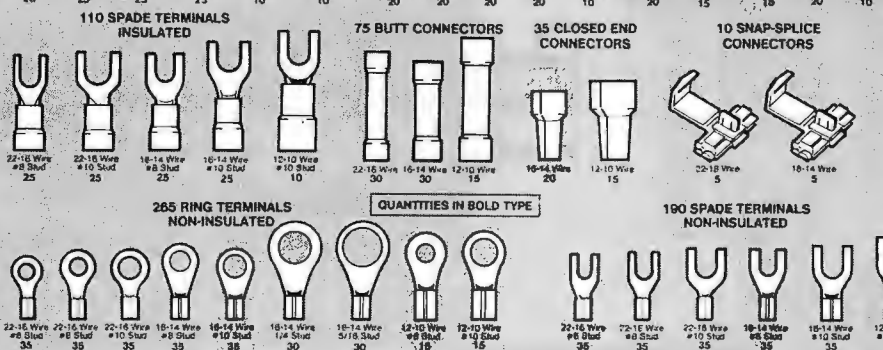
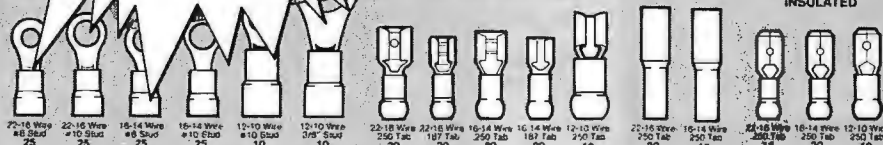
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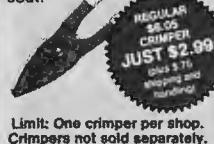
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Displays photographed separately to simulate typical appearance.

CIRCLE NO. 28 ON FREE INFORMATION CARD



New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Free Information Card or write to the manufacturer at the address given.

Hand-Held 50-MHz Counter

The Continental Specialties "Mini-Max" is a new hand-held automatic frequency counter that can be battery powered with a standard 9-V battery or, optionally, ac pow-



ered. It has a guaranteed minimum frequency range of from 1090 Hz to 50 MHz, with 100-Hz resolution throughout the entire range. There are no controls, only an on-off switch. The frequency is automatically displayed directly on the counter's 0.1" (2.54-mm) magnified, six-decade display, with leading zeroes blanked out. When the Mini-Max is first turned on, two decimal points (one each for kilo- and megahertz) come on in the display. It has a diode-protected miniature phone-jack input whose impedance is rated at 1 megohm. A built-in crystal-controlled timebase operates at 3.58 MHz and has a claimed frequency stability of 0.2 ppm/°C over a temperature range of from 0° to 50° C. Dimensions are 3" x 6" x 1 1/2". \$89.95.

CIRCLE NO. 88 ON FREE INFORMATION CARD

BGW Model 410 Power Amplifier

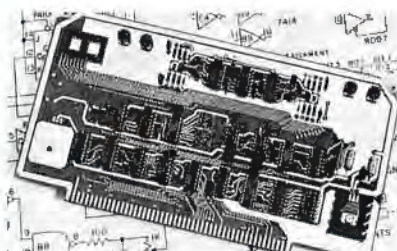


The Model 410 stereo power amplifier from BGW uses a pair of 10 discrete LED "meter" displays in place of the traditional analog mechanical movements to indicate output power. Rated at 200 watts continuous into 8 ohms, the amplifier's frequency response rating is 3 Hz to 100,000 Hz $\pm 0/-3$ dB. THD and IM distortion are rated at 0.05% and 0.01%, respectively. Residual hum and noise are rated at -110 dB. Input sensitivity is 2 volts for 200 watts output. The LED "meter" display is average responding; it has a three-position sensitivity switch (-20 , -10 , and 0 dB). A four-position speaker system selector switch with 20-ampere power-handling capability is provided. \$699.

CIRCLE NO. 89 ON FREE INFORMATION CARD

Vector Analog Interface Board

A multifunction Analog Interface Board for microcomputers, introduced by Vector Graphic Inc., is for use with potentiometers, joysticks, and voltage sources. An 8-bit digital port with a latch strobe can func-



tion as a keyboard input port. Tone pulse generators can also produce sounds for games or keyboard audio feedback. Additional features include four A/D inputs and MWRITE logic and a power-on jump feature for computers that lack a front panel. \$75, kit; \$115, assembled.

CIRCLE NO. 87 ON FREE INFORMATION CARD

Sansui Direct-Drive Turntable

The latest direct-drive turntable from Sansui, Model SR-333, is a two-speed manual player with individual pitch-control adjustments for each speed. The motor is a 20-pole, 30-slot brushless type, with wow and flutter rated by the manufacturer at less



than 0.035%. Rumble is rated at -70 dB, signal-to-noise ratio at better than 60 dB. The arm is an S-shaped, counterbalanced type. The SR-333 comes complete with base and dustcover. It measures 18 1/8" W x 6 1/16" H x 14 11/16" D. (46 x 15.4 x 37.9 cm), and weighs 17.2 lb (7.8 kg). \$200.

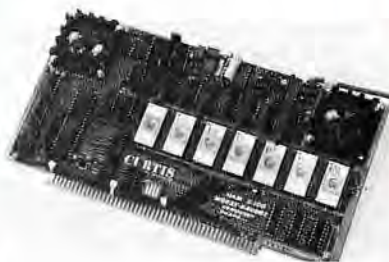
CIRCLE NO. 91 ON FREE INFORMATION CARD

Mobile Antennas for Japanese Cars

A new series of pillar-mount AM/FM/CB antennas, designed specifically to replace existing AM/FM antennas on Datsun, Toyota and Honda automobiles, has been announced by Harada. Five models are available: two each for Datsuns and Hondas, and one for Toyotas. The antennas are top-loaded for CB, with specially designed cables and couplers to accommodate all three reception modes.

CIRCLE NO. 92 ON FREE INFORMATION CARD

Curtis Amateur Radio Computer



A computerized Morse and Baudot code operating system for the ham is available from Curtis Electro Devices, Inc. Called the System 4000, it is designed to receive, decode, and print (via CRT) Morse or five-level Baudot TTY codes at rates of 10 to 100 wpm or 60 to 100 wpm. It also serves as a keyboard or paddle with CRT display of the transmitted text. The Morse keyboard provides a 500-key buffer, eight programmable message memories, and two

(Continued on page 22)

Why you should buy a digital multimeter from the leader in digital multimeters.

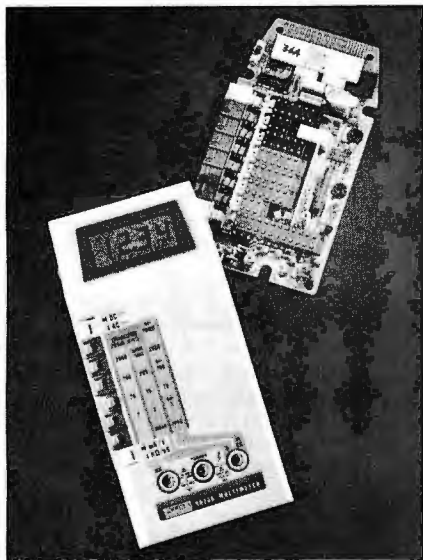
If you're shopping for your first multimeter, or moving up to digital from analog, there are a few things you should know.

First, look at more than price. You'll find, for instance, that the new Fluke 8020A DMM offers features you won't find on other DMMs at *any* price. And it's only \$169.*

Second, quality pays. Fluke is recognized as the leading maker of multimeters (among other things) with a 30-year heritage of quality, excellence and value that pays off for you in the 8020A.

Third, don't under-buy. You may think that a precision 3½-digit digital multimeter is too much instrument for you right now. But considering our rapidly changing technology, you're going to need digital *yesterday*.

If you're just beginning, go digital.



Why not analog? Because the 8020A has 0.25% dc accuracy, and that's *ten*

times better than most analog meters.

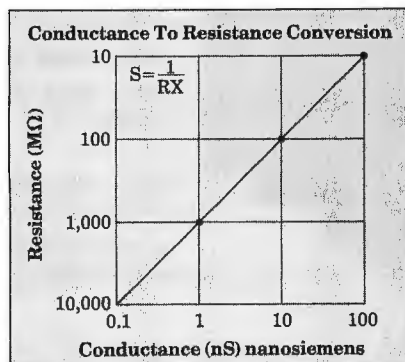
Also, the 8020A's digital performance means things like 26 ranges and seven functions. And the tougher your home projects get, the more you need the 8020A's full-range versatility and accuracy. The 8020A has it; analog meters don't.

If you're a pro.

You already know Fluke. And you probably own a benchtop-model multimeter.

Now consider the 8020A: smaller in size, but just as big in capability. Like 2000-count resolution and high-low power ohms. Autozero and autopolarity. And the 8020A has 3-way protection against overvoltage, overcurrent and transients to 6000V!

Nanosiemens?



Beginner or pro, you'll find the meter you now have can't measure nanosiemens. So what? With the 8020A *conductance* function, you can measure the equivalent of 10,000 megohms in nanosiemens. Like capacitor, circuit board and insulation leakage. And, you can check transistor gain with a simple, homemade adapter. Only with the 8020A, a 13-oz. heavyweight that goes where you go, with confidence.

What price to pay.



\$169.*

Of course, you can pay more. Or less. In fact, you could pay almost as much for equally compact but more simplistic meters, and get far less versatility. And, the 8020A gives you the 'plus' of custom CMOS LSI chip design, and a minimum number of parts (47 in all). All parts and service available at more than 100 Fluke service centers, worldwide. Guaranteed, for a full year.

Rugged. Reliable. Inexpensive to own and to operate; a simple 9V battery assures continuous use for up to 200 hours.

Where to buy.

Call (800) 426-0361 toll free. Give us your chargecard number and we'll ship one to you the same day. Or, we'll tell you the location of the closest Fluke office or distributor for a personal hands-on feel for the best DMM value going.

*U.S. price only

Fluke 8020A DMM for Home Electronics Experts: \$169



CIRCLE NO. 62 ON FREE INFORMATION CARD

NRI BRINGS "POWER-ON"
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FOR QUICKER, EASIER
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You get trouble-shooting experience from the chassis up . . . with NRI's unique training equipment.

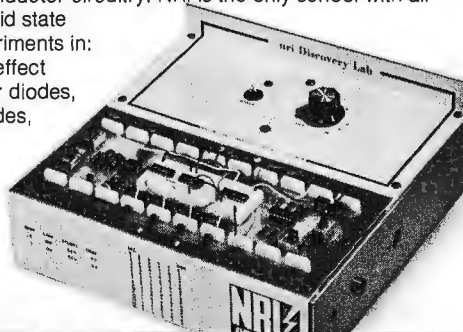
The "firsts" described here are typical of NRI's over 63 years of leadership in electronics home training. When you enroll as an NRI student, you get the technical knowledge and the priceless confidence of "hands-on" experience sought by employers in communications, TV-audio servicing, computers, and industrial and military electronics. NRI training is designed for your education . . . from the educator-acclaimed Achievement Kit sent the day you enroll, to bite-size, well illustrated, easy-to-read lessons programmed with designed-for-learning training equipment.

NRI Firsts make learning at home fast and fascinating. More than a million have come to NRI for home training. Professional TV/Audio technicians who learned their profession through home training rate NRI as first choice by far, over any other school.

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First and only school with new Optical Transmission System engineered to allow you to analyze digital and analog signal transmission via light beam. Systems you build use LED and phototransistor technology, simulating basic principles of laser communications as used in video disc home entertainment systems.

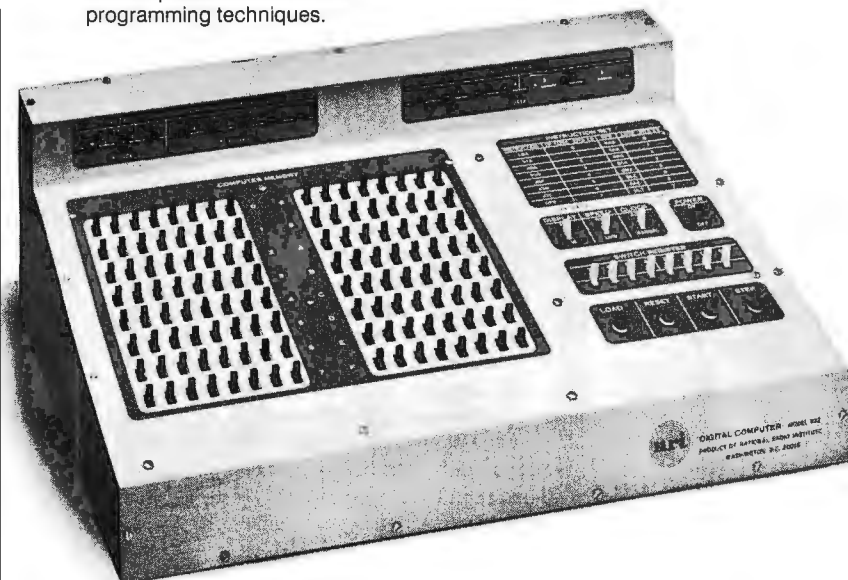
First and only school with designed-for-learning 25" diagonal solid state Color TV complete with cabinet. This solid state set was designed by NRI's own engineers from the chassis up so that students can perform over 25 in-set experiments during construction, including valuable "Power-On" trouble-shooting.



First and only school with a portable CMOS digital frequency counter engineered by NRI to give you experience in the newest types of digital systems coming into expanded use in consumer electronics.



First and only training with an actual programmable digital computer to give you the only home training in machine-language programming . . . essential to trouble shooting digital computers. Extra Memory Expansion Kit doubles memory size for practice in advanced programming techniques.



First and only school with a solid state regulated power supply engineered by NRI to give you experience with modern power supply designs; to give you a premium power supply for your NRI Transceiver, or to use in trouble-shooting mobile equipment.



First and only school with an Antenna Applications Lab engineered to give you a thorough understanding of practical communications antenna requirements. You assemble and test several different types of antennas and matching sections, measuring gain and radiation patterns.



First and only school with designed-for-learning, 400-channel, digitally-synthesized VHF Transceiver to give you the only fully-up-to-date 2-meter equipment for complete training in commercial, amateur, and CB communications. The design incorporates circuitry and components representative of the latest state of the art. Circuitry is on five plug-in circuit cards to take full advantage of NRI "Power-On" training.

If card is missing, write to:



NRI Schools
McGraw Hill Continuing
Education Center
3939 Wisconsin Ave.
Washington, D.C. 20016

(Continued from page 16)

fixed message memories (CQ and ID). The message memories are also available in the paddle keyer mode. Code speeds are adjustable in one wpm increments from 10 to 99 wpm. The System 4000 is designed to be added to the Processor Technology SOL-20 μ C, but it can be adapted to any S-100 bus, 8080-based μ C by adding additional I/O patches to the video driver and console keyboard. Address: Curtis Electro Devices, Inc., Box 4090, Mountain View, CA 94040.

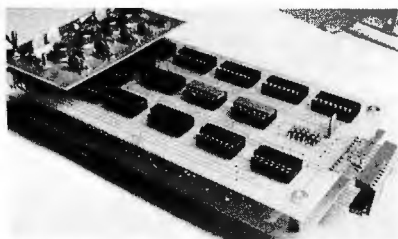
Bearcat Autoscan Monitor

The Electra Company's Bearcat 250 is a new automatic scanning receiver that monitors 50 channels, requires no crystals, and features auto search and recall. The synthesized scanner includes a nonvolatile memory, five custom-designed chips, and pushbutton programming for any frequency in five bands without the use of crystals. The receiver can monitor low and high vhf bands, the uhf band, the T band, and the 2-meter (146 to 148 MHz) ham band. The 50 channels are arranged in banks of 10. This is said to be the first scanner to automatically search out and activate local public-service frequencies, store them in memory, recall them on demand, and display the active frequencies discovered and stored during the search. It also contains a digital clock that operates while the scanner is performing other functions. A priority channel is built in. \$399.95.

CIRCLE NO. 93 ON FREE INFORMATION CARD

CCD Video Camera Kit

A charge-coupled device (CCD) video camera kit is available from Solid State Sales. The Model 202 camera can be used for both visible-light and infrared viewing,



and for character recognition with computers equipped with external circuits. It features the Fairchild 202C (100 \times 100 bit) self-scanning CCD as the graphic pickup element. Among the advantages claimed for the camera are: all clock voltages at a fixed level to eliminate the need for adjust-

ments; higher video output signal; simplified circuitry for easy assembly; and a two-level TTL output for easy interfacing. All components mount on two parallel boards. The output signal is for display on an X-Y oscilloscope. The camera kit comes with all semiconductors, passive components, boards, data sheets and diagrams, and an 8-mm lens. \$349.

CIRCLE NO. 9 ON FREE INFORMATION CARD

Mobile Entertainment Center With Clock

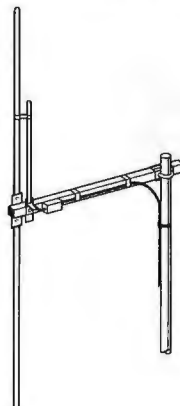
The Audiovox "Indasher" Model DGC-10 car stereo system contains an AM/stereo FM receiver, cassette player, and full-time clock (hours and minutes/day and date) and timer. Frequencies on AM and FM, time, and elapsed time are indicated by a yellow 7-segment numeric display. A push-button switch is provided for adjusting dis-



play intensity for daytime and nighttime driving conditions. The receiver is rated to deliver 10 watts rms and has 4- and 8-ohm outputs. The receiver portion features electronic AM/FM band selection, local/distance switch, and stereo/mono selection. The cassette player has fast-forward/eject/rewind lever and automatic eject mechanism at end of tape play. The time is continuously displayed until a station is tuned. Five seconds after a station is tuned, the display automatically switches back to the time-display mode. \$299.95.

CIRCLE NO. 95 ON FREE INFORMATION CARD

Finco Monitor Antennas



Two new monitor antennas—one for public-service bands and one for aircraft frequencies—have been announced by Finco. The SMA-1 Scanner Monitor Antenna operates as a $\frac{1}{2}$ -wave dipole in the 30-50-MHz lo-vhf band, as a $\frac{3}{2}$ -wave dipole in the 148-174-MHz hi-vhf band, and as a "J" stub in the 450-512-MHz uhf band. It is also available as SMA-1WK, a window-mounting kit with an 18' cable. The aircraft-monitor model AMA-3 is a half-wave, omnidirectional groundplane antenna tuned for the 108-138-MHz aircraft band, and is designed to mount on $\frac{1}{4}$ " mast or standard 1" threaded water pipe (not included).

CIRCLE NO. 96 ON FREE INFORMATION CARD

Underwater Microphone/ Earphone

The Y² Model IO-310 is an underwater microphone rated by its manufacturer for depths of up to 600 feet. It can also be used as an earphone. Specifications are: sensitivity, -85 dB re 1 V/microbar; impedance, 2000 ohms at 1 kHz; electrical leakage resistance greater than 100 megohms; weight, $\frac{3}{4}$ oz (23 g); size, 1.2" dia. \times $\frac{3}{8}$ " thick (3.0 \times 1.0 cm). \$16.95. Address: Y-Square Associates, Inc. 2001 So. Eastwood St., Unit "A", Santa Ana, CA 92705.

AM CB Base-Station Transceiver



The Robyn Model AM-500D AM CB base station transceiver is rated to deliver 4 watts of output power with a 100% modulation limit on all 40 CB channels. It features a large LED-type numeric channel indicator, illuminated SWR and S/r-f meters, and separate transmit (TX) and receive (RX) indicators. Pushbutton switches control PA/CB selection, ANL (automatic noise limiter) in/out selection, and choice of internal or external speaker. Separate rotary controls are provided for adjusting VOLUME, SQUELCH, RF GAIN, TONE, MIKE GAIN, and SWR/CAL. The dual conversion receiver is

(Continued on page 24)

Radio Shack's personal computer system? This ad just might make you a believer.

You can't beat
the 4K system at
\$599



- TRS-80 "Breakthru"**
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 - 12" video display
 - Professional keyboard
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(Continued from page 22)

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The KLH Model 693DMSC is a 3-way,
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use. Its woofer is 6 X 9 in., with a 30-oz
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A hand-operated nibbling tool for cutting
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New Literature

SYLVANIA SEMICONDUCTOR GUIDE

GTE Sylvania has announced availability of
the 1978 ECG Semiconductor Master Re-
placement Guide. This catalog (\$2.95) lists
over 137,000 industry part numbers cross-
referenced to the Sylvania ECG semiconduc-
tor line. A wide assortment of domestic and
imported replacement solid-state devices is
presented for entertainment, commercial,
and industrial/MRO applications. Also includ-
ed in this publication are outline drawings, cir-
cuit diagrams and technical descriptions of
transistors, diodes, rectifiers, SCR's, Triac's,
and others. Address: GTE Marketing Serv-
ices Center, 70 Empire Dr., West Seneca, NY
14224.

H-P CALCULATOR BROCHURE

A new, six-page brochure from the Hewlett-
Packard Company describes the HP-19C
and the HP-29C keystroke programmable
advanced scientific calculators that feature
98 fully merged program steps, continuous
memory, full editing and storage functions
and 30 data registers. The HP-19C has a
built-in thermal printer. Included in the bro-
chure are sections describing the advanced
programming features of the two calcula-
tors—including branching, subroutines, in-
direct control functions, and editing—a sum-
mary of keyboard features, and physical
specifications. Address: Hewlett-Packard
Company, 1507 Page Mill Rd., Palo Alto, CA
94304.

EXACT INSTRUMENT CATALOG

Exact Electronics, Inc., has released a 66-
page catalog containing specifications for
each frequency synthesizer and function/
waveform generator in its product line. A
comparison chart simplifies instrument selec-
tion. Address: Exact Electronics Inc., Box
160, Hillsboro, OR 97123.

B&F SURPLUS ELECTRONICS CATALOG

The 32-page "Clean-Sweep-Sale" catalog
available from B&F Enterprises features
speaker kits, surplus I/O terminals, a 16-watt
stereo amplifier kit, regulated 10-30V 5A
power supply kit, plus surplus bargains for
the hobbyist and engineer. Photos and dia-
grams are also included. Address: B&F En-
terprises, 119 Foster St., Peabody, MA
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Stereo Scene

By Ralph Hodges

FOR THE RECORD—II

EVERY couple of years the engineering department at Shure Brothers mounts a day-long technical seminar for interested members of the audio press. Invariably these seminars are *events*, not only because they generally herald the unveiling of an important new product, but especially because they bring to light research conducted by the company over the intervening period.

A word about the nature of this research is in order before we go any further. There now exists a considerable body of literature on the subject of record playing, attempting to deal with such matters as tracing distortion, record and stylus wear, mass-compliance considerations in negotiating modulations scribed on a vinyl surface, etc. As a result, the mechanics of record playing have become well enough understood to make it obvious that they are not very well understood at all. Probably what is most lacking is the solid underpinnings of empirical data to support the theoretical conclusions that have been offered. Records differ, one from another, in a surprising number of crucial ways; so do phono cartridges, given the inevitable vagaries of assembling a tiny and complex electromechanical device that can be sold at an affordable price. This raises the problem of accumulating enough experimental evidence to be statistically significant—a problem that Shure has been attacking for some years. The company does not claim to be even close to the ultimate answers, but what it has discovered from playing a great number of records a great number of times with a variety of pickups adds up to a unique body of data.

At the latest seminar, Shure engineers told a somewhat bemused audience of audio writers that: (1) electrostatic charges on record surfaces can have pernicious effects on record-player performance, not the least of them being alterations of tracking force of up to 3/8 gram; (2) that mechanical damping, properly applied, is of benefit when play-

ing the (warped) records available in the real world; that cartridge vertical tracking angle is still a matter of serious concern, although the effects of minor errors (a degree or so) continue to defy objective and subjective analysis; (4) that time-domain distortions such as warp wow are gaining further recognition as major faults in record-player performance; and (5) that record and stylus wear, subjects of profound mysteriousness, can be tied down to a few more generalizations.

Getting Static. Shure finds that your typical phonograph record can accumulate a static charge (negative) of up to 30,000 volts. Above that point the breakdown potential of the surrounding air is reached and static charges are carried off. Surprisingly, the actual business of playing the record does not seem to contribute significantly to the charge. Removing the record from its protective sleeve appears to be the major culprit.

Because vinyl is an effective insulator, these static charges tend to be local, cropping up in distinct patches where (presumably) the record surface has been in intimate sliding contact with the interior of the sleeve. Therefore, although the record will exhibit a measurable and fairly constant "macrofield" from some distance away, the pickup will pass through a series of "microfields" as it negotiates each revolution of the record. The magnetic attraction these fields exert will pull the cartridge to the record, compressing the stylus assembly and giving rise to—of all things—a warp-wow effect. Shure's Roger Anderson demonstrated this by first playing a discharged record with steady test tones (fine) and then after scrubbing a small section of the record with a popular record-cleaning appliance (not so fine). A distinct warble in pitch was heard with every rotation.

The conclusion to be drawn is that the patchy occurrences of static charge on the record can have enough influence on the tonearm/cartridge combination to

significantly alter (or wobble) the tracking force. Evidently the effect is quite significant when the tracking force is as low as 1 gram. In fact, Shure's measurements of the variations are in large part based on differences in tracking ability of the cartridge when the static charge (and hence the mutual attraction of disc and pickup) is increased.

No indictment of record-cleaning devices was intended by this demonstration. In fact, Shure generally approves of them. However, discharging or neutralizing the record before it is played is obviously advisable. Its close proximity to the turntable platter (if metallic) will obviously help somewhat, as will the use of anti-static "pistols" available from a number of manufacturers. But a better way is probably afforded by the disc-tracking record cleaners with conductive (and grounded) bristles.

Getting Damped. The application of mechanical damping to the typical record-playing system is likely to be beneficial, Shure has decided, as long as the damping is applied at the proper place and in the proper amount. The proper place is said to be as near the stylus as possible, and the proper amount will of course depend on the characteristics of the cartridge and the effective mass of the tonearm structure, assuming negligible bearing friction. The effects of properly applied damping (with the Shure/SME 3009 tonearm) can be seen in Fig. 1. The damping mechanism being used is an integral part of a new Shure cartridge model (of which more a bit later), and its contribution is said to be a hefty reduction of output at the infrasonic tonearm/cartridge resonance.

What does this reduction mean in a practical sense? There are several interdependent ways of looking at it. According to Shure spokesmen: (1) There is much less infrasonic energy reaching the amplifier and loudspeakers, which

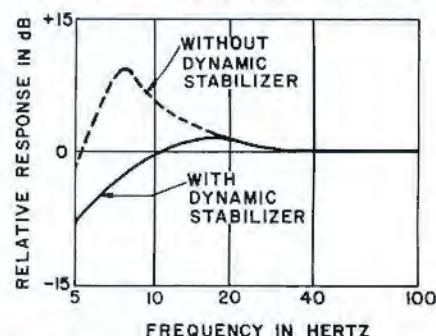


Fig. 1. Curve shows effects of use of dynamic stabilizer, as measured by Shure.

"The Sansui AU-717 is a superb amplifier. We like it with no ifs, ands, or buts." (Julian Hirsch)
It offers "as much circuitry sophistication and control flexibility as any two-piece amplifying system."
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"The preamplifier section of the AU-717 has very

impressive specifications for frequency response, equalization accuracy, and noise levels ... The AU-717 has dual power supplies, including separate power transformers, for its two channels ...

[and] exceptionally comprehensive tape-recording and monitoring facilities Good human engineering separates this unit from some otherwise fine products....

"The Sansui AU-717 is a superb amplifier. We like it with



Julian D. Hirsch, Contributing Editor Stereo Review

no ifs, ands, or buts." [Reprinted in part from Julian Hirsch's test report in *Stereo Review*, February, 1978.]

"One clear advantage of DC design is apparent. Even at the low 20Hz extreme, the amplifier delivers a full 92 watts — the same value obtained for midfrequency



Leonard Feldman, Contributing Editor Radio-Electronics

power — compared with its 85 watt rating into 8 ohms....

"The equalization characteristic of the preamplifier was one of the most precise we have ever measured, with the deviation from

the standard RIAA playback curve never exceeding more than 0.1dB.....

"Sansui claims that this unit has reduced transient intermodulation distortion — a direct result of the DC design, and, indeed, the model AU-717 delivered sound as transparent and clean as any we have heard from an integrated amplifier....

"... worth serious consideration — even by those who prefer separate amplifiers and preamplifiers." [Reprinted in part from Len Feldman's test report in *Radio-Electronics*, January, 1978.]

Listen to the superb sound of the Sansui AU-717 at your Sansui dealer today. And be sure to ask him for a demonstration of the matching TU-717 super-tuner.

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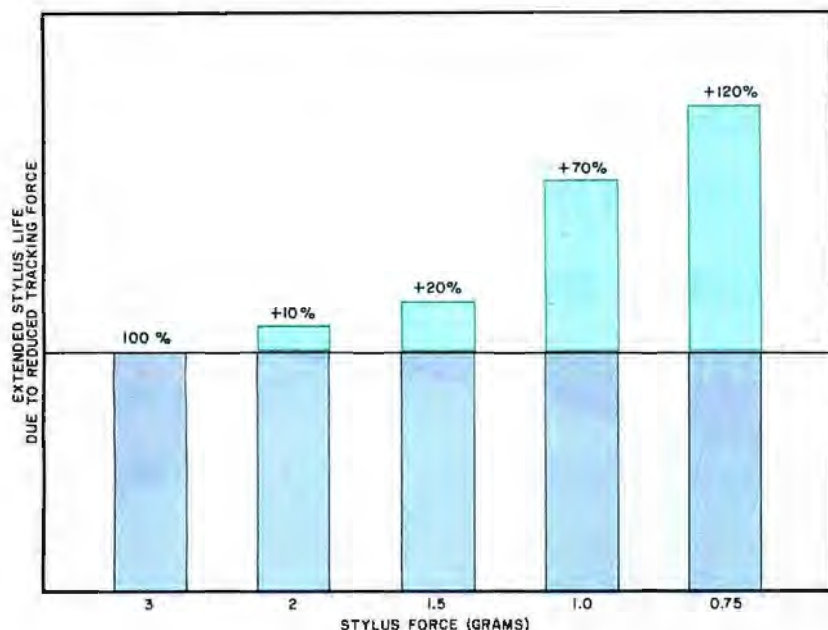


Fig. 2. Shure's studies suggest that stylus forces of 1.5 grams are best for reduced stylus wear.

means much less effort on their part in attempting to reproduce something that is musically inconsequential. (2) There is, by inference, much less stylus motion at these infrasonic frequencies, which means that the musical information on the record won't be frequency-modulated by warps and ripples in the record surface to as great a degree as heretofore. (3) There is an improvement in tracking ability at infrasonic frequencies. According to Shure, tracking ability is directly related to stylus force, and is therefore a commodity that can be used up cumulatively (just as your telephone bill reduces the resources you have to pay your gas and electric bill). Thus an improvement in tracking ability at infrasonic frequencies (present on most records, which are inevitably far from perfectly flat) means more tracking ability left over for the musical information on the disc.

Getting Worn. The perennial questions of consumers as to how long their styli or their records can be expected to last remain unanswered. However, there are some general conclusions that can be drawn at this time. (1) According to Shure, stylus wear is closely related to tracking force, no matter what the configuration of the stylus (conical, elliptical, Shibata, etc.). The bar graph in Fig. 2 illustrates this, and shows why Shure recommends a maximum of 1.5 grams on tracking force. (2) Playing the same record over and over for a given number of hours is likely to result in more stylus

wear than playing different records for a comparable length of time. The reason for this seems to be a build-up of abrasive agents in the record groove—in particular, diamond dust from the stylus which has become embedded in the groove during previous plays. (3) A certain amount of wear is inevitable on present-day records when played with present-day cartridges. Even after the first play, sophisticated instruments can detect a shallow trough gouged by the stylus upon the groove walls. To a certain extent this is beneficial; the smoothing of the groove-wall surface improves the signal-to-noise ratio. But after this burnishing of the groove has taken place, any further alteration of its shape is likely to be detrimental.

An interesting sidelight: Shure's experimental results indicate that, on records with simple sine-wave test tones, the wearing process can actually reduce the level of harmonic-distortion products by as much as 66 percent.

Getting a New Cartridge. The new top-of-line Shure phono pickup, the V15 Type IV, is of course an attempt to cope with all the newly documented phenomena discussed above. Like its predecessors it has a flip-down stylus guard that remains as functional as ever. But the stylus guard has grown a little beard of conductive carbon-fiber bristles that draw off static charges from the record surface. It is also supported by a pair of viscous-damped pivots that make it an effective damping mechanism for the arm-

cartridge resonance. And finally, the little beard is an effective record cleaner, although that is a secondary function and no substitute for a thorough cleaning of the record before any attempt to play it. (See Hirsch-Houck's test report on the new V15, this issue.)

All in all, the conclusions drawn by Shure's research are highly provocative.

On Another Front. Stanton's remarkable stylus for playing record stampers (Fig. 3) has been fairly well publicized in recent months. It solves—or at least comes as close as possible to solving—a weighty problem on the mind of every record manufacturer: How can I tell whether the molding parts (the stampers) for my record are any good before going to the expense of having them clamped into a press to produce a few test pressings? Because it is a mold, the nickel stamper has ridges instead of grooves, and anything intended to play these ridges must straddle a peak instead of plumbing a depression. The illustration explains much better than words could how the Stanton special-application stylus accomplishes its task, but there's another side to the story as well.

According to Stanton, the stamper-playing stylus has turned out to be a remarkably good tip for the reproduction of 78-rpm records. No explanation has yet been given for this, other than the fact that the stylus's outer dimensions are appropriate for the wider grooves on 78-rpm records (as are, indeed, the dimensions of tips sold especially for 78-rpm reproduction). Pending a thorough examination of exactly what is going on, Stanton may decide to offer the stylus to consumers (it fits the cartridge bodies for the 681 and 680 model series). A consumer price schedule has not yet been created, however. ◇

Fig. 3. Special Stanton stylus plays ridges on metal stampers with a two-point configuration.



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(Parametric Equalizers by SAE)

SAE has long been involved in the field of tone equalization. From our pioneering efforts in variable turn over tone controls to our more recent advancements in graphic equalizers, we have continually searched for and developed more flexible and responsive tone networks. From these efforts comes a new powerful tool in tone equalization — the Parametric Equalizer. Now you have the power of precise control.

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With either of these equalizers, you have the power to correct any listening environment or overcome any listening problems that you are faced with. Whether you need a third octave notch filter, tailored bandwidth to resurrect a vocalist, or a tailored cut to bury an overbearing bass, the control flexibility of Parametric Equalizers can fill these needs and many more. And of course, as with all SAE products, they offer the highest in sonic performance and quality of construction.



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HOW NECESSARY IS SELECTABLE I-F BANDWIDTH IN AN FM TUNER?

ABOUT four years ago, the first consumer-model FM tuner with selectable i-f bandwidths (the Yamaha CT-7000) made its appearance. In a tuner selling for some \$1200, one would expect features not found on more mundane products, and the provision for wide and narrow i-f bandwidths seemed to be perfectly reasonable for a pace-setting product. Competition being what it is, other tuners have since joined the "wide/narrow" fraternity. The Nikko Gamma I, reviewed this month, is a good example, and its \$300 price brings this feature within the reach of almost every audiophile.

If it were possible to make ideally shaped i-f filters, there would be no need to offer a choice of bandwidths. It is necessary to accept a bandwidth of at least 150 kHz (and undesirable to have it wider than 200 kHz) if a tuner is to receive undistorted programs from any station in an alternate-channel relationship to any other station (a "worst case" example).

Practical filters do not have flat tops or infinitely steep rejection slopes. At least as important as the amplitude response of a filter is its phase response. Group delay distortion can cause different sideband frequencies to pass through the filter in different time relationships, resulting in severe distortion and loss of stereo separation. Generally, it is necessary to compromise filter design to obtain satisfactory phase and amplitude characteristics.

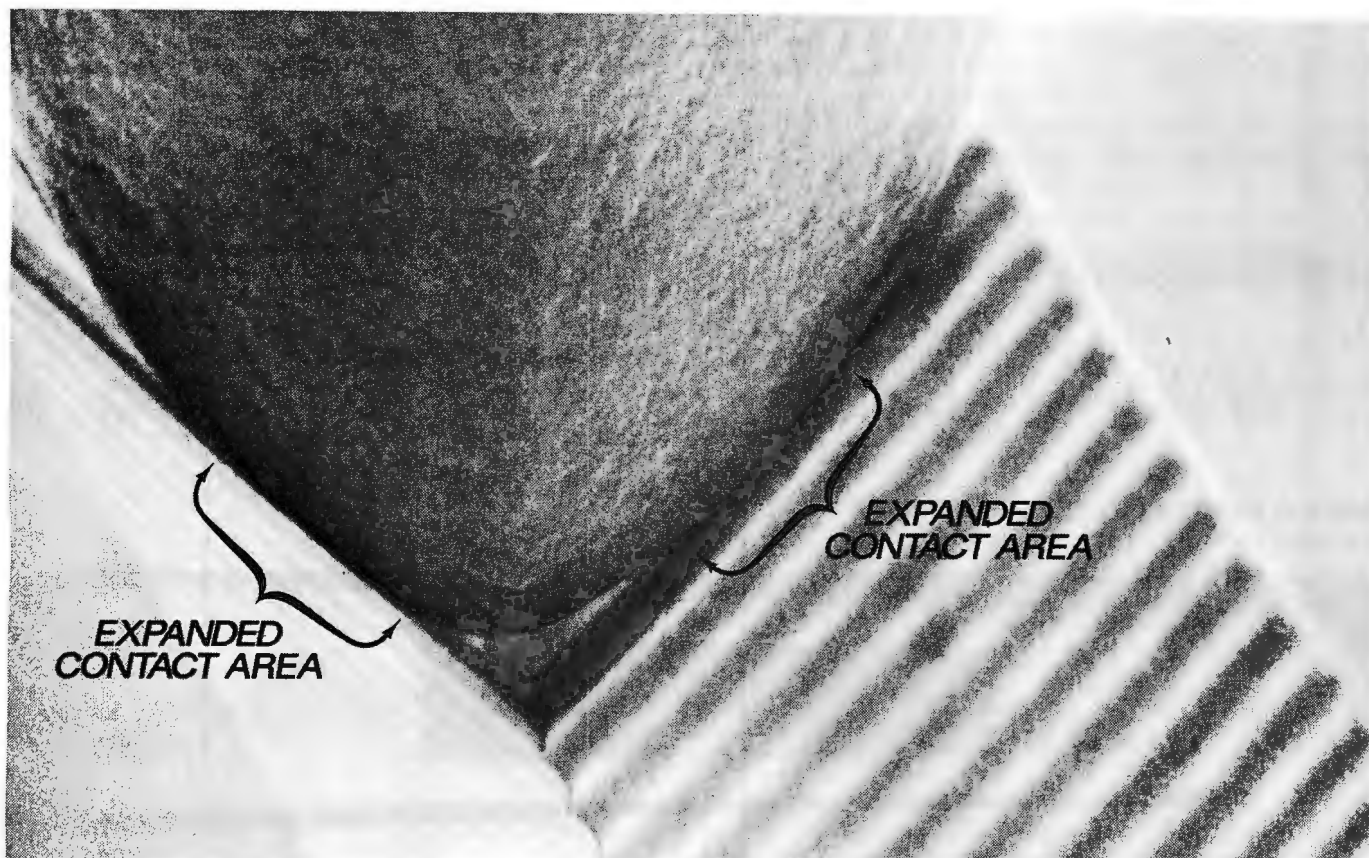
If a tuner has a single i-f bandwidth, it thus represents a compromise between selectivity and distortion (as well as stereo channel separation, to some degree). The fact that some tuners achieve very respectable performance in all categories with a single filter system is a testimonial to the care and expertise that went into their design. However, if one wishes to obtain the best of both worlds (high selectivity and low distortion) from an FM tuner, it is necessary to have two i-f bandwidths available. Sometimes, as in the case of the Yamaha CT-7000, the two are obtained from entirely different i-f amplifiers, each designed for optimum performance. It is also possible to switch filters, using most of the i-f amplifier components in common with both modes of operation.

To illustrate the advantages of a dual bandwidth system, consider some typical selectivity values (alternate channel) for single bandwidth tuners. A fairly good tuner might have an IHF selectivity rating of 60 to 70 dB, combined with a stereo harmonic distortion of perhaps 0.15 to 0.2%. These are certainly very adequate performance figures for most people, especially since they are obtainable in some rather moderate-priced tuners and receivers.

Suppose, however, that one is in the unfortunate position of living near a fairly strong station that broadcasts rock music 24 hours a day, while the nearest classical is 50 miles away and only 400 kHz from the local transmitter (rock enthusiasts can feel free to interchange the programming of the two stations!). Assuming that one's tuner front end does not overload from the local signal, which is another matter entirely, it is likely that you will need all the selectivity you can get. A more expensive tuner might improve the selectivity rating to 80 or even 90 dB without serious compromise in distortion or other factors. To get more than about 90 dB selectivity (100 dB or even more is possible), a tuner with a super-narrow i-f filter is required. The distortion and channel separation of your favorite classical station may be impaired, but probably not enough to be objectionable. The alternative might possibly be not receiving the station at all!

Now suppose your second favorite station is fairly close to your location, quite strong, and transmits very-high-quality programs. Being a purist, you may not wish to settle for "only" 25 to 30 dB of channel separation, though it might be sufficient. It is possible to "eat one's cake and have it, too" with a tuner having switchable i-f bandwidths. For the "easy" listening situation, the wide bandwidth may reduce stereo distortion to well below 0.1% and increase channel separation to 45 dB or even more. The sacrifice is in selectivity, which may be as low as 20 or 25 dB. But, if the station is in the clear, that will pose no problems. I have found no trouble when listening to most stations in the spectrally crowded New York area with a tuner having that order of selectivity.

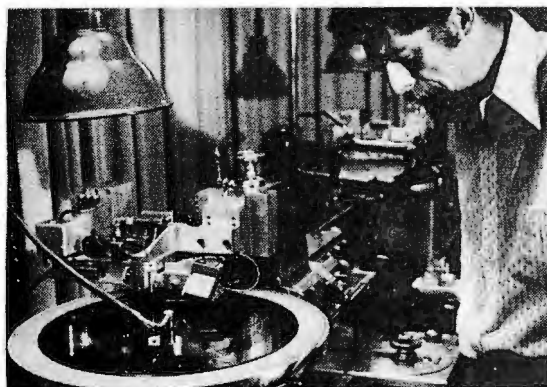
Better stereo records are the result of better playback pick-ups



© Stanton Magnetics, Inc., 1977

Scanning Electron Beam Microscope photo of Stereohedron Stylus; 2000 times magnification. Brackets point out wider contact area.

Enter the New Professional Calibration Standard, Stanton's 881S



Mike Reese of the famous Mastering Lab in Los Angeles says: "While maintaining the Calibration Standard, the 881S sets new levels for tracking and high frequency response. It's an audible improvement. We use the 881S exclusively for calibration and evaluation in our operation"

The recording engineer can only produce a product as good as his ability to analyze it. Such analysis is best accomplished through the use of a playback pick-up. Hence, better records are the result of better playback pick-up. Naturally, a calibrated pick-up is essential.

There is an additional dimension to Stanton's new Professional Calibration Standard cartridges. They are designed for maximum record protection. This requires a brand new tip shape, the Stereohedron®, which was developed for not only better sound characteristics but also the gentlest possible treatment of the record groove. This cartridge possesses a revolutionary new magnet made of an exotic rare earth compound which, because of its enormous power, is far smaller than ordinary magnets.

Stanton guarantees each 881S to meet the specifications within exacting limits. The most meaningful warranty possible, individual calibration test results, come packed with each unit.

Whether your usage involves recording, broadcasting or home entertainment, your choice should be the choice of the professionals... the STANTON 881S.



For further information write to Stanton Magnetics, Terminal Drive, Plainview, New York 11803

I have been asked if one can determine just how much selectivity is needed in any given situation so that one can decide whether or not a more selective tuner is required, or if a wider bandwidth will suffice. Unfortunately, no firm answer can be given to that question. There are too many variables involved. About all that can be said with certainty is that, if you experience interference from alternate channel stations (400 kHz spacing) in the form of a program breaking through on to another station, you need more selectivity! Whether a specific degree of selectivity is adequate for your needs is impossible to say. Sometimes the trouble can be cured without involving the tuner. If the two stations concerned are not in the same direction from your location, a good directional antenna can sometimes be used to correct the problem. Such an antenna can reduce the level of the

stronger signal by a greater amount than it reduces the level of the weaker one; this alone can sometimes eliminate the interference.

I have this situation in my own home, where one tuner suffers badly from interference by an alternate channel station, yet others (on different antennas) are completely free of the problem. Moving the offending tuner to another part of the house, on a different antenna, corrected the problem. If I were to insist on listening at the original location to those stations, a better tuner would certainly be the answer.

So, to answer the question posed by the title, a choice of i-f bandwidths is a nicety for most people, but a necessity for others. At prices over \$1000, most of us can do without it very well. But at \$300, it becomes one of the more attractive and useful features to look for when buying a tuner.

NIKKO GAMMA I STEREO FM TUNER

Features wide and narrow i-f bandwidths.



In spite of its compact dimensions, the Gamma I FM tuner from Nikko has a full complement of operating features and controls. Topping the list is the tuner's selectable

i-f bandwidth that allows the user to trade capture ratio and selectivity for greater channel separation and lower distortion. Other features included are: switchable 25/75- μ s deemphasis, FM detector output, oscilloscope outputs that provide a multipath display, and

both fixed and variable level audio signal outputs. The tuner has a 19" (48.3-cm) wide front panel, which makes it rack-mountable, although its 2½" (6.4-cm) height does not conform with EIA standards for rack-panel heights. Depth is 9" (23 cm).

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Product Focus

The Nikko Gamma I is one of the small, but growing number of FM tuners that offer a choice of wide or narrow i-f bandwidths. This is done by using two separate i-f amplifiers between the mixer output and the limiter output. Both are driven simultaneously from the mixer, through FET stages that isolate them from each other. Their outputs are also joined, but through diodes that can be switched from conducting to nonconducting states by a dc control voltage, through the switch used for WIDE/NARROW bandwidth selection.

The common terminal of the output coupling diodes goes to an IC amplifier/limiter stage that also provides signal-

strength and channel-center tuning indications on the meters on the front panel, interstation noise muting, and some of the multipath information to the jacks in the rear of the tuner, for viewing on an external oscilloscope. According to the schematic, the comprehensive i-f IC stage also includes a quadrature detector, which apparently supplies only the tuning signal to the center-channel meter. A separate IC limiter and a ratio detector are actually used to derive the audio signal, presumably because of the lower distortion resulting from a separate optimized detector circuit.

In the selective i-f system, the narrow-band amplifier consists of four pairs of

ceramic filters, with gain supplied by three IC stages, in a conventional configuration. The wide-band amplifier consists of two IC stages and two filters. One filter is a relatively large, cased unit identified as a "phase linear filter" (there are no visible clues as to its internal construction), while the other is a ceramic filter that, judging from its size, is rather more complex than the ceramic i-f filters used in most FM tuners (and in the narrow-band amplifier of the Gamma I). The special qualities of these filters presumably lie in their combination of wide bandwidth and linear phase shift, both of which are required for low-distortion stereo FM performance.

PERFORMANCE SPECIFICATIONS

Specification	Rated	Measured
Usable sensitivity (mono)	10.3 dBf, 1.8 μ V	14 dBf, 2.7 μ V
50-dB quieting sensitivity		
Mono	14 dBf, 2.7 μ V	16.5 dBf, 3.7 μ V
Stereo	34 dBf, 28 μ V	38.6 dBf, 47 μ V
S/N at 65 dBf		
Mono	78 dB	68.5 dB
Stereo	75 dB	67.5 dB
Hum (re: 100% modulation)	NA	-65 dB
THD at 65 dBf		
Mono:		
Wide	0.04%	0.057%
Narrow	0.08%	0.155%
Stereo:		
Wide	0.06%	0.044%
Narrow	0.2%	0.47%
Frequency response (30-15,000 Hz)	+0.4/-0.8 dB	+0.9/-0.8 dB
Capture ratio		
Wide	1.0 dB	1.0 dB
Narrow	1.5 dB	2.0 dB
Alternate-channel selectivity		
Wide	35 dB	39.8 dB
Narrow	80 dB	81 dB
Adjacent-channel selectivity		
Wide	NA	4.9 dB
Narrow	NA	9.9 dB
Spurious-response suppression	110 dB	NA
Image-response ratio	110 dB	greater than 106 dB
I-f response ratio	110 dB	NA
AM suppression	60 dB	70 dB
Stereo separation at 1000 Hz		
Wide	55 dB	46.5 dB
Narrow	45 dB	54 dB
Stereo separation (50-10,000 Hz)		
Wide	35 dB	31 dB
Narrow	32 dB	31 dB
Subcarrier product rejection	65 dB	98 dB
Muting threshold	10 dBf, 1.7 μ V	19.8 dBf, 5 μ V
Output level at 1000 Hz (varies)	1.3 V maximum	1.45 V maximum

It weighs 12.1 lb (5.5 kg). Its nationally advertised value is \$350.

General Description. As is the case with some other tuners and receivers we have seen, the Gamma I's stereo/mono selector and muting circuit activator are combined in a single control. Hence, muting can be employed only in the automatic stereo mode. (Of course, mono signals will be heard perfectly well in this mode.) For reception of weak signals where it is necessary to disable the muting, the tuner operates in the mono mode; a stereo signal would not be listenable under these conditions.

The panel dimensions of the tuner allow only a single row of controls to be used, with the dial window occupying about half of the panel width. The calibration marks on the tuning scales are linearly distributed. Actual tuning is by a very smooth flywheel mechanism that is noteworthy considering that the internal height of the tuner does not permit the use of a large-diameter flywheel.

The two meters indicate relative signal strength and center-channel tuning.

In addition to the large TUNING and OUTPUT LEVEL control knobs and a toggle-type POWER switch, there are three pushbutton switches on the front panel of the tuner. The buttons are for selecting WIDE or NARROW IF BAND, switching in and out the HI-BLEND circuit, and for selecting STEREO or MONO MODE of operation. LED's located just above each button come on when the various functions are activated. Another LED inside the dial window comes on when a stereo signal is received.

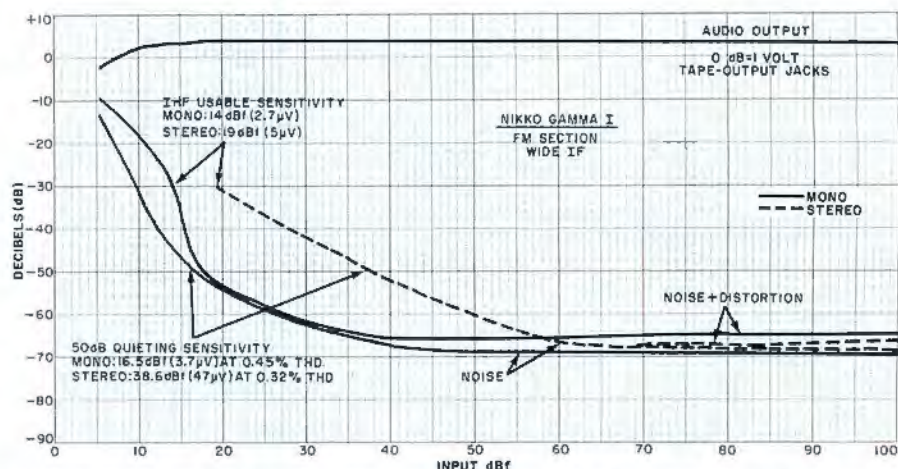
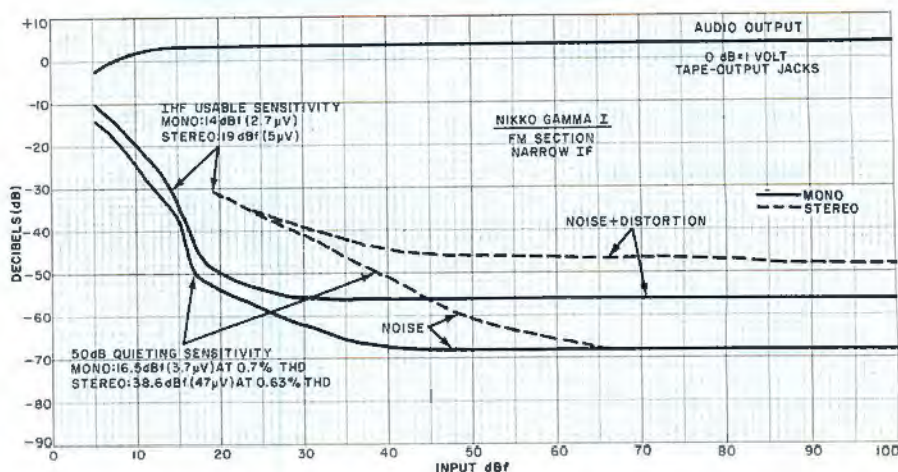
User Comment. The Gamma I can fairly be described as a no-frills "super tuner." We base this description on the fact that the Gamma I has exceptionally high interference rejection and sensitivity, distortion that is lower than the residual levels of the finest signal generators, flat frequency response, and stereo channel separation that is far greater than that of any broadcast station. In fact, only the S/N performance and residual hum (both of which were quite satisfactory but not exceptional) prevent the Gamma I from rivaling the performance of some tuners that cost several times this tuner's price. It should also be noted that although the measured sensitivity of our test tuner fell a couple of decibels short of its published ratings, it still had far more sensitivity than most people will ever need.

That such a high level of performance

is available for its stated price and in such a compact component is testimony to the state of modern technology and a tribute to Nikko's designers, who appear to have resisted the temptation to dilute their efforts with marginal or purely cosmetic features. Nothing that could contribute to the useful performance of the Gamma I has been omitted.

We preferred to use the tuner in its wide-band mode, which reduces the distortion to well below the rated capabilities of our Sound Technology signal generator. The Gamma I retained enough selectivity in this mode to let it be used without difficulty on the crowded FM band in the New York metropolitan area. Perhaps the most surprising test result was the 19-kHz pilot carrier rejection figure of 98 dB, which was barely within the measurement capabilities of our Hewlett-Packard spectrum analyzer. In spite of this, the tuner's frequency response was almost perfectly flat to 15,000 Hz. This indicates that it has unusually effective low-pass filters in its audio circuits or some form of pilot-carrier cancelling circuitry. (No schematic was furnished with the tuner.) In either case, there should be no problems when it is used with a tape recorder or a Dolby noise-reduction accessory.

The "feel" of the tuning mechanism and general handling ease of the Gamma I were excellent. The muting action was ideal, with no transient noises and a complete silence until the pointer was well into the center of the scale of the tuning meter. Although it was marked only at 0.5-MHz intervals, the dial cali-



Noise and sensitivity curves for narrow (top) and wide i-f bandwidths.

bration was very accurate and left no doubt as to what station was being received. In short, the Gamma I proved to be one of the most functional and listen-

able tuners we have used, in spite of, or perhaps because of, a near-total lack of gimmickry and cosmetic devices.

CIRCLE NO. 101 ON FREE INFORMATION CARD

FISHER MODEL CR-4025 CASSETTE DECK

Wireless control unit has "Pause" for remote on-off recording purposes.



The Fisher Model CR-4025 cassette deck features a wireless remote control PAUSE

function that permits recording and playing back of tapes to be interrupted and resumed from a location some distance from the deck. The front-loading deck also has a single governor-controlled dc motor and two tape heads. It has built-in Dolby B noise-reduction circuitry, tape bias and equalization switching for normal (ferric-oxide) and chromium-dioxide (CrO₂) tapes, and selectable line and microphone inputs.

The deck measures 15 1/8"W x 11 3/8"D x 6"H (38.4 x 30.2 x 15.2 cm) and

weighs 13 lb 10 oz (6.2 kg). Its nationally advertised value is \$249.95

General Description. The recording levels for the two channels are independently adjustable. However, the line and microphone inputs cannot be mixed. Playback level from the deck is fixed.

Illuminated VU meters permit monitoring of both the record and the playback levels over a range of -20 to +5 dB. (The standard Dolby reference mark is at the +3-dB point on the meter scales.) The microphone input and stereo headphone output jacks are located on the front panel of the deck. On the rear apron are the phono-jack LINE inputs and outputs and a control shaft for ad-

justing the sensitivity of the remote-control system.

The transport controls are operated by mechanical levers located below the hinged door into which the cassette is placed. The levers can be operated in any sequence without having to go through STOP. The transport mechanism has an automatic shutoff and mechanical disengagement system at the end of the tape in the PLAY mode, but it does not operate in the fast-forward and rewind modes.

The STOP/EJECT lever stops tape motion when first operated. Releasing and operating it again causes the cassette door to pop open for easy removal of the tape from the deck.



The remote-control transmitter, which is about the size of a 100-mm cigarette package, contains an ultrasonic generator and transducer. A receiving module is located behind the front panel of the deck. When the transmitter is aimed at the deck and a button on its side is pressed, a solenoid in the deck energizes the PAUSE lever and a red LED near the receiver's input grille comes on to indicate that the transport is in the pause mode. A second operation of the transmitter's button releases the solenoid and restores normal operation.

Laboratory Measurements. Since the owner's manual makes no specific recommendations for tapes for which the deck has been matched, we initially ran a series of record/playback curves with tapes we had on hand. With the NORMAL setting of the BIAS switch, there was little difference between the curves; we obtained with most tapes, including Scotch Dynarange and Master I, Memorex MRX2, BASF Professional I, and Maxell UD-XL I. The somewhat "hotter" TDK AD tape yielded a slightly rising high-end response, which other tapes did not produce. The flattest response, by a small margin, was obtained with Maxell UD-XL I tape, which we used for our subsequent tests with the NORMAL switch setting.

We made similar measurements with Scotch Master II, Maxell UD-XL II, TDK SA, Sony CrO₂ and BASF Professional II tapes for the CrO₂ setting of the bias switch. (Sony CrO₂ and BASF Professional II were the only true chromium-dioxide tapes in the group.) The three

"chrome equivalent" ferric-oxide and the Sony chrome tapes gave nearly identical response curves, but BASF Professional II was clearly the best of the group with our test deck. (Its excellent compatibility was later confirmed by Fisher.)

The frequency response at a -20-dB recording level, with Maxell UD-XL I tape, was within ± 1.5 dB from 60 to 14,500 Hz. With the chrome BASF Professional II, the response was nearly the same, except that it was noticeably flatter throughout most of the high-frequency range. At 0 dB, the saturation we observed with the UD-XL I tape was typical of most two-head tape recorders. The response curve gradually fell beyond 6000 Hz and intersected the -20-dB curve at 11,700 Hz. As expected, the chrome tape was considerably better in its high-frequency saturation properties, so that the 0-dB curve dropped off more gradually and never intersected the -20 dB curve.

The "tracking" of the Dolby circuits was measured at recording levels of -20, -30, and -40 dB. The net change in frequency response, with the Dolby system in and out of the circuit, was quite noticeable at the two higher levels, amounting to 3 or 4 dB at most frequencies from 2000 or 3000 Hz up to about 13,000 Hz. (The Dolby Laboratories specifications allow a ± 2 dB variation.)

The playback equalization was measured with a TDK AC-337 test tape for NORMAL (120- μ s) equalization, and with the Teac 116SP tape for CrO₂ (70- μ s) equalization. The normal response was within ± 0.6 dB from 40 to 12,500 Hz, and the CrO₂ response was within ± 1

dB from 40 to 10,000 Hz. (These were the frequency limits of the test tapes.)

For a 0-dB recording level, a LINE input of 67 mV or a MIC input of 0.13 mV was required. The MIC input overloaded at a fairly low level of 23.5 mV. The playback level from a 0-dB recording was 0.80 volt with Maxell UD-XL I tape and 0.71 volt with BASF Professional II tape. The playback distortion (third harmonic) from 1000-Hz recordings at 0 dB were 0.63% and 1.8%, respectively, with these tapes. The reference distortion level of 3% was reached at recording inputs of +7 dB with UD-XL I and +3 dB with the BASF tapes. The S/N, relative to these levels, was 56.5 and 50.5 dB, respectively, in an unweighted measurement. With "A" weighting, they improved to 61.5 and 59.5 dB. Finally, us-

Product Focus

The most obviously novel feature of the Fisher Model CR-4025 cassette deck is its wireless remote-control PAUSE system. The hand-held transmitter is powered by a pair of AA cells and generates a 40-kHz ultrasonic signal when a button on its side is pressed. This is picked up by a small ceramic microphone element behind a grille on the front panel of the cassette deck and amplified by an IC. A gain control (sensitivity adjustment) follows the IC, and from it, the signal goes to a transistor stage that has a 40-kHz tuned circuit in its collector circuit. After further amplification, the ultrasonic signal is rectified. The dc output from the rectifier is amplified to the point where it can activate a solenoid that moves the PAUSE lever to its ON position. The PAUSE lever latches into place until the next application of a control signal operates the solenoid again and turns it off. The solenoid is operated from a separate power supply rectifier. (Judging from its size, it may well consume more power than the rest of the recorder.)

The basic recorder circuits are conventional and unusually simple. Each channel employs a single IC, three transistors, and a moderate number of discrete components for most of its recording and playback gain and equalization functions. In addition, there is an IC for the Dolby noise-reduction system in each channel and a few discrete components for the audio LINE outputs and metering circuits. (The meter rectifiers are driven from the headphone outputs.) The bias/erase oscillator is packaged as a separate module in a sealed metal can.



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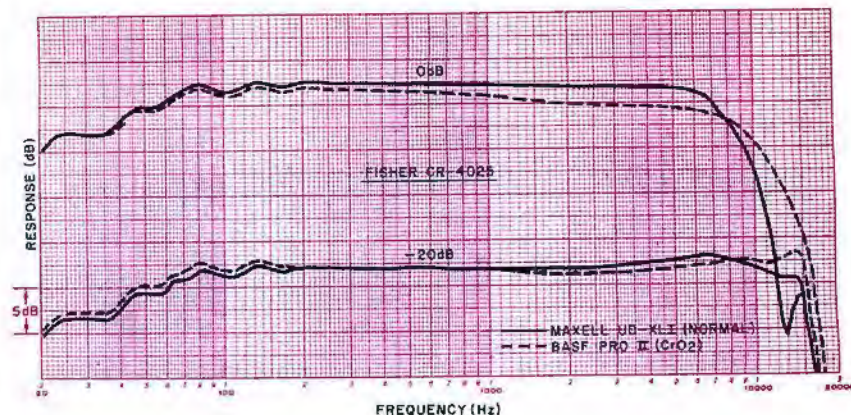


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Frequency response for two types of tape at 0 and -20 dB.

ing the Dolby system and CCIR/ARM weighting, the S/N was a very respectable 66 dB with either tape. The noise level increased by 18 dB through the mic inputs at maximum gain, but the increase was correspondingly less at reduced gain.

The weighted rms wow/flutter was 0.095%, and a weighted peak measurement (DIN) gave a $\pm 0.15\%$ reading. The speed of the tape transport was about 1% fast. In fast forward and rewind, a C60 cassette was moved from end to end in 82 and 85 seconds, respectively. The channel separation at 1000 Hz, measured with a TDK AC-352 tape, was 58 dB. The Dolby level calibrations on

the meter were accurate to within 0.5 dB. The meters themselves proved to be very accurate and matched standard VU-meter ballistics exactly. They indicated 100% of steady-state on 0.3-second tone bursts. The headphone volume was low with 200-ohm phones, although it might have been adequate with 8-ohm phones.

User Comment. The deck met or surpassed its specified performance ratings, which were typical of cassette decks in its price class. The major concessions to price in its design appear to be in the absence of such niceties as an end-of-play shut-off from high speed

PERFORMANCE SPECIFICATIONS

Specification	Rated	Measured
Wow & flutter	0.09% W rms	0.095% W rms
S/N ratio	50 dB 56 dB with Dolby	50.5 dB (CrO ₂) 66 dB with Dolby (CCIR/ARM weighting)
Erase ratio	70 dB	Not measured
Channel separation	35 dB	58 dB
Crosstalk	68 dB	Not measured
Frequency response	± 3 dB, 40-14,000 Hz (CrO ₂ tape)	± 3 dB, 38-14,800 Hz (CrO ₂)
THD at 0 VU	1.8%	1.8% (CrO ₂)
Tape speed variation	$\pm 1.2\%$	+1.0%
Rewind/FF time	100 seconds	85/82 seconds (C60)
Mic inputs	0.2 mV/600 ohms	0.13 mV

operation, memory rewind, mixing of recording inputs, and playback level adjustment. To compensate for these omissions, it has the remote PAUSE feature, which we found to be quite useful. It always worked well, with enough sensitivity to operate from anywhere in the room. As Fisher suggests, the remote

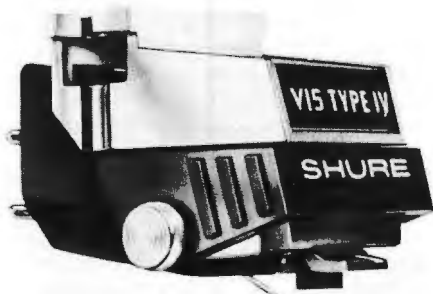
PAUSE is especially convenient for recording off the air or from records, allowing a certain degree of "editing" while recording without requiring the operator to be in two places at the same time.

Playing good recorded tapes, such as the Advent CR/70 series, the deck sounded first rate. Also, when we re-

corded interstation FM tuner hiss and compared the playback to the original, there was very little discernible difference between the two. When recording from FM broadcasts and records, the sound from the Model CR-4025 gave no hint that the playback was not from the original source.

SHURE MODEL V15 TYPE IV STEREO PHONO CARTRIDGE

Record-cleaning brush damps low-frequency tonearm/cartridge resonance.



Heading the top of Shure's phono cartridge line is the new Model V15 Type IV.

Aside from a damper and static neutralizer (see Product Focus), the basic phono transducer functions of the Type IV have been refined to a new high in performance. The stylus effective mass has been reduced from the Type III's 0.33 mg to 0.29 mg. The cartridge employs a new "hyperelliptical" stylus that is claimed to result in lower tracking distortion at high frequencies. The Type IV also offers a slightly greater output than its predecessor, the Type III. In a departure from Shure's practice for its top-of-the-line cartridges over the past few years, the Type IV is designed to deliver its flattest frequency response when loaded with 200 to 300 pF of capacitance and 47,000 ohms (in contrast, the Type III was designed to operate into a 400-to-500-pF load).

Supplied with a No. VN45HE hyperelliptical stylus, the Model V15 Type IV's nationally advertised value is \$150.

General Description. While the Type IV physically resembles the Type III cartridge, the new cartridge's mounting holes have been redesigned to simplify installation in a tonearm headshell. It incorporates a threaded nut plate that fits into the body of the cartridge and eliminates the need for separate nuts to mount the cartridge.

Like the Type III, the Type IV is designed to track at forces in the range of

0.75 to 1.25 grams. However, to compensate for the weight of the brush assembly on the cartridge's stylus guard, the tonearm's tracking force must be set 0.5 gram higher so that the force registered at the stylus itself is in the range of 1.25 to 1.75 grams.

Shure was able to effect reduced mass in the stylus cantilever by using a smaller diameter alloy tube. The tube was strengthened with the aid of a stiffening rod at the pivot end. The damping material at the pivot end of the cantilever is decoupled in a graduated manner to improve trackability at high frequencies.

The frequency response of the new cartridge is rated at ± 1 dB up to 8000 Hz and ± 2 dB up to 20,000 Hz. The trackability at a 1-gram stylus force has been increased at all frequencies, especially between 5000 and 10,000 Hz and in the warp range between 8 and 15 Hz.

Laboratory Measurements. We installed the cartridge in the tonearm of a Dual Model 701 record player to perform

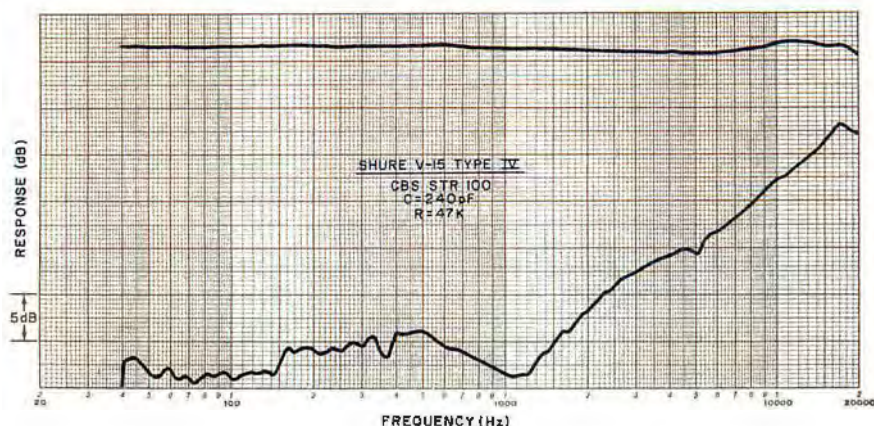
our lab tests. Except where noted otherwise, our tests were performed at a 1-gram tracking force.

At a 1-gram force, the cartridge easily tracked our most severe test records. It could play the 300-Hz tones on the German Hi Fi Institute record to their 70-micron level, which is good hi-fi cartridge performance, at 0.75 gram and to 80 microns at 1 gram. The record's maximum level of 100 microns was playable without distortion at the cartridge's maximum rated tracking force of 1.25 grams. The output of the cartridge at 3.54 cm/s was 3.85 mV, with a channel balance of 0.5 dB (rated 4 mV and 3 dB).

The IM distortion measured with Shure's TTR102 test record was as low as we have ever measured. It was typically about 1% and reached a maximum of only 2% at the record's maximum velocity of 27 cm/s. Similarly, the high-frequency tracking test with the shaped 10,800-Hz tone bursts on the Shure TTR-103 record revealed nearly constant repetition rate distortion between 0.7% and 0.9% over the full 15-to-30-cm/s range of the record. The fact that neither distortion measurement exhibits appreciable variation over a wide range

PERFORMANCE SPECIFICATIONS

Specification	Rated	Measured
Frequency response	10-25,000 Hz (± 1 dB to 8 kHz, ± 2 dB to 20 kHz)	40-20,000 Hz ± 0.8 dB
Output voltage	4.0 mV at 1000 Hz, 5 cm/s	3.85 mV at 1000 Hz, 3.54 cm/s
Channel balance	2 dB	0.5 dB
Channel separation	25 dB at 1000 Hz 15 dB at 10,000 Hz	30 dB at 1000 Hz 18 dB at 10,000 Hz
Tracking force	0.75 to 1.25 g at stylus tip 1.25 to 1.75 g with Dynamic Stabilizer	— —
Load	47 kilohms paralleled with 200 to 300 pF	47 kilohms paralleled with 240 pF



Composite response and crosstalk using CBS STR100 test record.

of recorded velocities suggests that the measurement is the residual distortion in the records and the associated test instruments, rather than inherent distortion from the cartridge itself.

Our frequency response measurements with the CBS STR100 test record confirmed Shure's rating. The response was flat to within ± 0.8 dB from 40 to 20,000 Hz. Channel separation is rated at a minimum of 25 dB at 1000 Hz and 15 dB at 10,000 Hz. Our measured figures were 30 and 18 dB, respectively. The frequency response was not materially affected by rather large changes in load capacitance (150 to 375 pF).

The damper worked with impressive effectiveness. It completely eliminated the usual rise at bass resonance and, in fact, produced a slight rolloff in bass response below about 20 Hz. The difference in bass output with the damper latched up and in its normal position was about 7 dB at 9 Hz and 1 dB at 20 Hz. No measurements were made of the destaticizing properties of the brush, aside from visual observations. The brush did remove visible amounts of dust from the records we played.

User Comment. The sound of the Model V15 Type IV is much like that of the Model V15 Type III, which also has a very flat frequency response. We doubt that the two cartridges could be distinguished by ear when playing most records. The best way to demonstrate the improved performance of the Type IV is to play records that tax the abilities of the Type III, but be prepared to find very few such records.

One test that highlights the difference between the cartridges is on the older Shure TTR110 "Audio Obstacle Course—Era III" test record. Some strain and incipient mistracking can be heard on the highest levels of the sibi-

lance test with the Type III (and almost every other cartridge). At 1 gram, the Type IV was able to handle every part of this record with a complete lack of strain that is rarely encountered even with the finest cartridges. We also tried the completely different material on the new "Era IV" test record but obtained no definitive results. Those obtained with the "Era IV" record were not as easy to interpret as with the "Era III" record, perhaps because the cartridge was able to track it so completely without trouble.

The Type IV appears to be a cartridge that has the "most" of every desirable quality and the "least" of every undesirable quality. It is unsurpassed in the smoothness and flatness of its frequency response, low distortion, high trackability, and neutral sound character. It appears to effectively remove static charges and dust (both from the surface and the grooves) of records.

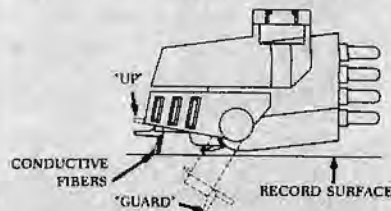
The cartridge's damping effect at bass resonance is accomplished in a manner that surpasses every other cartridge known to us. Aside from any audible benefits the damper might bestow on record playing, it makes a dramatic improvement in the tracking of warped records. We verified this with a number of warped records that were literally unplayable with other cartridges. Almost all of them were playable with the Type IV, which acted like it was glued to the surfaces of the records. We noted very little tendency for the cartridge to lift from the record surface at the crest of a warp.

About the only shortcoming of the Type IV is its rather high price, although this is certainly not the only phono cartridge in the \$150 price range. Most important, with the Type IV, one gets very tangible improvements in performance instead of a cosmetic updating or unnecessary fancy packaging.

Most of the innovative aspects of the Shure Model V15 Type IV phono cartridge are not visible to the eye. Some are not even easy to measure with instruments. However, the cartridge's feature that sets it apart from other cartridges is its hinged stylus guard that is part of its removable stylus assembly.

Close examination reveals that a small brush is built into the lower portion of the stylus guard. It measures about $\frac{1}{4}$ " (6.4-mm) wide and is designed to ride on the surface of the record just ahead of the stylus. There is nothing new about record brushes, even when they are attached to a cartridge, but the brush on the Type IV is rather unique. It consists of some 10,000 tiny graphite fibers, each of which is about 0.3 mil in diameter. In addition to removing dust from the record during play, about 10 of the fibers can fill a record groove to reach in and remove dust from the walls and bottom of the groove.

A more effective record-cleaning brush cannot by itself qualify as a novel cartridge feature. The difference with the brush on the Type IV cartridge is that the graphite fibers are electrically conductive. This plus the fact that the stylus guard is made of metal and is wired through to a ground terminal of the cartridge's signal outputs is what makes the brush unique. As a record is played, electrostatic charges that build up on its surface are drained off to ground. This keeps the net charge relatively low.



There are several advantages to neutralizing the static charge on a record being played. First, the vertical tracking force of the cartridge is not increased by electrostatic attraction, which can otherwise add several tenths of a gram to the net force. Second, the tendency of the vinyl record material to attract dust is greatly reduced. And, third, the crackling and popping sounds generated by electrostatic discharges while playing a record are eliminated or reduced.

The final contribution of the guard assembly is perhaps most important. The pivots of the guard are viscous damped so that the entire assembly acts as a damper for the low-frequency tonearm/cartridge resonance. The rise in the output of the cartridge at some low bass frequency, usually in the range of 8 to 10 Hz, is eliminated by the damping action and the tracking of warped records is greatly improved.

Before you buy a DC integrated amp,
find out how much DC you're getting.



Pure DC. From input to output. With each amplifier-stage direct coupled (DC). With no capacitors in between. From the pre-amp to the power amp. That's what makes Technics SU-8080 a true DC integrated amp. But that's just one of the reasons for buying it.

Waveform fidelity is another. With the major source of phase shift, noise and distortion eliminated, Technics engineers were able to increase the frequency response of the SU-8080 to DC~100 kHz -1 dB. And that means the SU-8080 can accurately reproduce waveforms, toneburst signals and square waves. Imagine how accurately it reproduces music.

To the SU-8080's DC pre-amp our engineers added an extremely quiet phono equalizer complete with Technics-developed ultra-low-noise transistors. The result: An increased phono S/N ratio of 100 dB at 10 mV with sharply reduced circuit and transistor noise, especially when compared to conventional designs. They also added some rather unconventional controls. Like a subsonic filter in the phono equalizer and a four-step phono impedance selector.

And to match our DC integrated amp, there's our equally impressive matching ST-8080 tuner.

Two RF stages with low-noise 4-pole dual-gate junction FETs combined with a linear FM variable tuning capacitor boost sensitivity while greatly reducing interference signal levels. At the same time, Technics-developed flat group delay filters in the IF (Intermodulation Frequency) stage increase selectivity without increasing distortion.

There's also a Phase Locked Loop IC in the MPX circuit as well as a pilot signal canceler for razor-sharp cancellation of the 19 kHz pilot signal and ruler-flat high-end response: 20 Hz to 18 kHz ($+0.2$ dB, -0.8 dB).

Now that you know what DC does for the SU-8080 integrated amp and the matching ST-8080 tuner, find out what DC does for their specs.

SU-8080 Amp. POWER OUTPUT: 72 watts per channel min. RMS into 8 ohms from 20 Hz to 20 kHz with no more than 0.02% total harmonic distortion.

POWER SECTION S/N (IHF A): 115 dB. PHONO S/N (IHF A): 100 dB (10 mV). INPUT SENSITIVITY: 1 V/47k Ω .

ST-8080 Tuner. 50 dB QUIETING SENSITIVITY: Mono 13.6 dB. Stereo 34.3 dB. SELECTIVITY: 85 dB. THD: Mono 0.15%. Stereo 0.3%. CAPTURE RATIO: 1.0 dB.

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test, or use its matching mini antenna for easy RF checking. Either way, the input is protected against overload to 50V (100V below 1 KHz).

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Protect Your AIR CONDITIONER WITH A "COMPRESSOR GUARD"

Add-on device prevents compressor damage due to sudden loss and reappearance of electric power and low-voltage conditions.

BY RICHARD B. FERMOYLE

POWER BLACKOUTS and brown-outs, especially during hot spells when the demand for power is at its peak, can cause damage to air-conditioners, refrigerators, and freezers. You can protect your compressor-type appliances from damage due to fluctuating power with the "Compressor Guard" described in this article. It costs about \$15 to build and is easily installed.

Problem Defined. If power to the compressor is suddenly lost and reapplied before system pressures can be equalized, such as during a momentary power outage, damage to the system compressor can result. A low-voltage condition, commonly called "brownout," can also cause damage. In both cases, the damage usually takes place



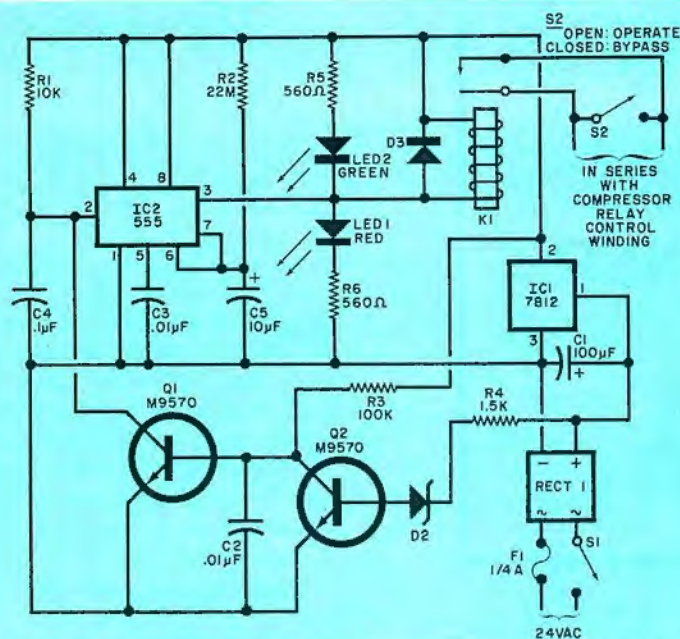


Fig. 1. Circuit provides 4.5 min. delay before power is applied.

PARTS LIST

C1—100- μ F, 50-volt electrolytic
 C2,C3—0.01- μ F disc capacitor
 C4—0.1- μ F disc capacitor
 C5—10- μ F Tantalum capacitor
 D2—Zener diode (see text)
 D3—1N4001 rectifier diode
 F1—1/4-ampere fast-blow fuse and holder
 IC1—7812 voltage regulator
 IC2—555 timer
 K1—Spst relay with 12-volt coil and 1-ampere contacts (Radio Shack No. 275-003 or similar) or appropriate substitute (see text)
 LED1,LED2—Discrete light-emitting diode

(one red, one green)
 Q1,Q2—M9570 or similar npn transistor
 The following resistors are 1/4-watt, 10%:
 R1—10,000 ohms
 R2—22 megohms
 R3—100,000 ohms
 R4—1500 ohms
 R5,R6—560 ohms
 RECT1—50 PIV bridge rectifier assembly
 S1,S2—Spst switch
 Misc.—Socket for IC2; chassis; 4-conductor cable; rubber grommets; machine hardware; hookup wire; solder; etc.

in the compressor's drive motor as a result of overheating due to excessive current drain.

Unfortunately, the compressor and its associated drive motor are generally contained in a single sealed unit in home appliances. This means that the entire unit must be replaced as one expensive component. Although the drive motor for the compressor is usually equipped with a thermal circuit breaker, it takes time for it to sense an overload condition and disable power to the motor. The problem here is that during the time the overload condition exists, before it is sensed and power is cut off, the motor can stall and burn out. Repeated momentary power outages take their toll in weakening the motor, with the result that the motor is ultimately damaged even with the thermal circuit breaker in proper operating condition protecting the circuit.

The Compressor Guard circuit described here can be added to any compressor-type appliance to provide an added degree of protection.

How It Works. As shown in Fig. 1, the Compressor Guard is built around a 555 timer integrated circuit (IC2). The power source for the timer circuit is 24 volts ac, which is taken from the appliance itself. In the case of a central air-conditioning system, the 24 volts is supplied by the system's step-down transformer, as

shown in Fig. 2. This transformer is part of the air-conditioning control circuitry and supplies power to the compressor's control relay through the contacts of the house thermostat. If the house is too warm, the thermostat closes and energizes the control relay, which in turn supplies power to the compressor unit. (Note: If the compressor system operates at a higher voltage, a separate 24-volt source and a relay with contacts rated for high voltage and current must be used in addition.)

The 24 volts ac is converted to regulated dc by RECT1, C1, and IC1 in Fig. 1 to supply power for the timer circuit. Approximately 4.5 minutes after power is applied, pin 3 of IC2 switches low and energizes relay K1. The period is controlled by R2 and C5. With the K1 contacts closed, a series circuit with the system's thermostat is completed. The compressor can then energize. If a momentary power outage occurs, a minimum of 4.5 minutes must lapse before power can be reapplied to the compressor. This period of time is all that is needed to allow system pressures to equalize and the compressor to be safely started once again.

The low-voltage brownout protection feature of the Compressor Guard is provided by the Q1 and Q2 circuits. The breakdown voltage rating of zener diode D2 is approximately 7% to 10% less than the normal dc output potential of RECT1. As long as the output potential from RECT1 is greater than the breakdown point of D2, Q2 is in a state of conduction and Q1 is held at cutoff.

If system line voltage drops, a resultant decrease in the output potential from RECT1 will occur. If the potential drops to less than the breakdown voltage of D2, Q2 goes into cutoff and Q1 conducts. This grounds pin 2 of IC2, caus-

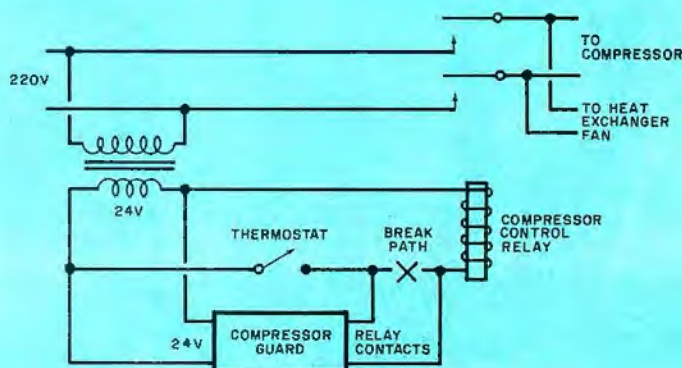


Fig. 2. Circuit showing how to wire Compressor Guard to existing system.

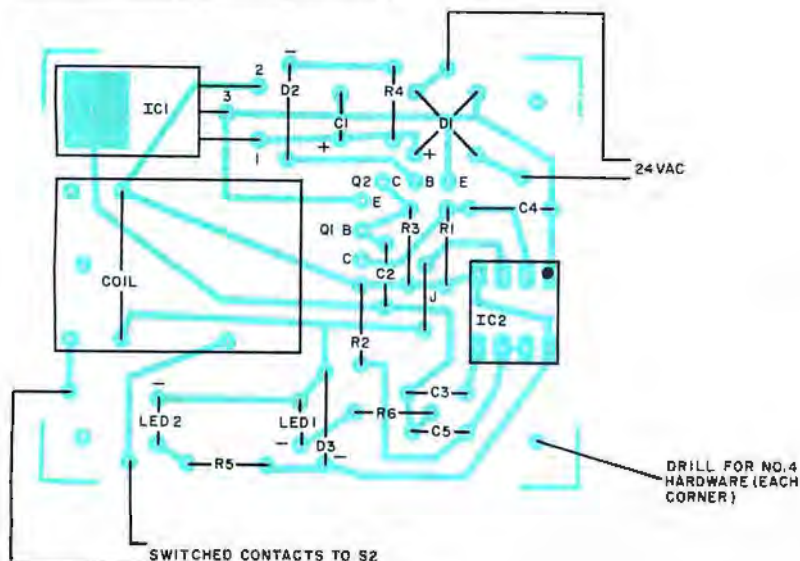
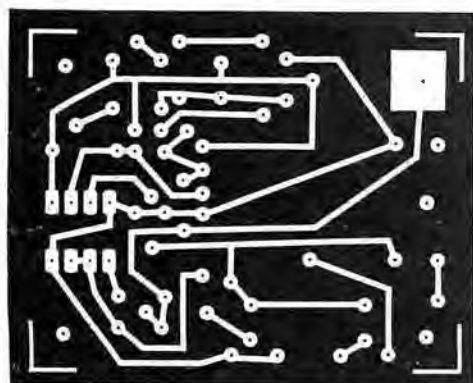


Fig. 3. It is best to assemble the circuit on a printed circuit board. An etching and drilling guide is at top with component placement guide shown below it.

passed by closing S2. This shorts out the contacts of K1. Switch S2 is included in the circuit to allow system maintenance to be performed.

Construction. Most of the circuit is best assembled on a printed circuit board, the etching-and-drilling guide and component-placement diagram for which are shown in Fig. 3. A small right-angle bracket is used as a heatsink for regulator IC1.

Since the pc board assembly mounts behind the front panel of the cabinet in which the circuit is housed, LED1 and LED2 (if used) should be mounted on the foil side of the board. Leave enough lead length on the LED's to permit the lenses to fit into small rubber grommets in the front panel when the board is mounted in place with spacers and machine hardware. The fuse holder for F1, power switch S1, and OPERATE/BYPASS switch S2 should also be mounted on the front panel.

The 24-volt power and relay contact lines can be contained in a four-conductor cable that enters the cabinet through a rubber-grommet-lined hole in the front panel. The assembled printed circuit board is shown in Fig. 4.

To install the Compressor Guard in a system, use the diagram shown in Fig. 2 as a guide. Although Fig. 2 is the representation of the typical scheme used in most central air-conditioning systems, check your system closely to insure compatibility with the Compressor Guard's circuitry. Also, if you are using the Compressor Guard to protect a refrigerator or freezer that does not have the stepped-down 24 volts required, be sure to use a separate 24-volt supply and a heavy-duty relay.

With the Compressor Guard turned on and the compressor running, measure the dc output potential from RECT1. Then multiply the figure obtained by 0.93 or 0.90 to obtain the approximate breakdown value of the zener diode required for D2. If you cannot obtain a zener diode with the proper breakdown voltage, use two zener diodes that, when connected in series, yield a breakdown characteristic that is as close as possible to the required value.

One Last Note. The Compressor Guard presented here has been designed for inside installations. If you plan to use it in an outside air-conditioning installation, be sure to provide adequate weather proofing to protect the circuit from the elements. ♦

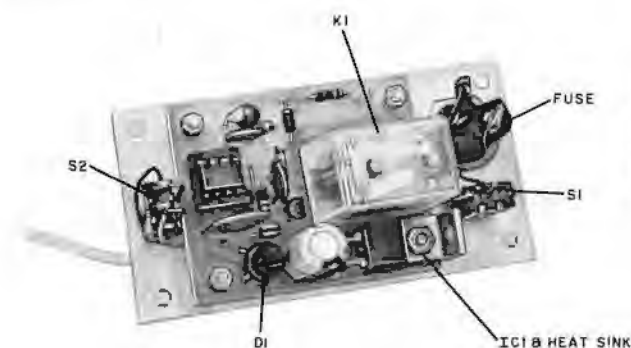


Fig. 4. Photo of prototype printed circuit board removed from enclosure.

ing pin 3 of IC2 to switch high and deenergizing K1. As long as the low-voltage condition exists, K1 remains deenergized and interrupts power to the compressor. About 4.5 minutes after the brownout condition clears, K1 energizes to once again supply power to the compressor system.

Status indication of the timer circuit is

provided by LED1 and LED2, which are red and green light-emitting diodes, respectively. While the timer is cycling LED1 is on. Then, when K1 is energized, LED1 extinguishes and LED2 comes on. The LED's and resistors R5 and R6 are not essential to the circuit and can be omitted if desired.

The Compressor Guard can be by-



Add Fuzz TO YOUR ELECTRIC GUITAR OR BASS

BY JAMES BARBARELLO

*Solid-state fuzz box
for interesting
sound effects.*

ELECTRIC guitarists often use special circuits to alter the sounds their instruments produce. One of the oldest but still most popular of these signal modifiers is the "fuzz box." A solid-state circuit, the fuzz box generates a sound like that produced by early, low-cost vacuum-tube power amplifiers. When one of these amps was overdriven, a distorted, but pleasing sound resulted. The fuzz box, when controlled by a foot pedal, allowed the guitarist to introduce some "fuzz" without interrupting his performance to turn up the amp's gain.

Many different fuzz box designs have appeared over the years. The project presented here, is a somewhat different sine-to-square-wave converter. It produces a substantial output signal, even when used with inexpensive instruments. Its "fuzz" effect is as prominent in the bass as in the midrange and treble. In addition to the standard distortion effects, the circuit can produce a raspier, but at the same time mellow, voicing. The circuit's wide range of available output levels allows the user to preset different levels for the rhythm and lead modes. The project is especially useful with electric bass guitars because it can generate many of the effects called for in today's music without sacrificing the bass's characteristic deep tones.

The circuit is simple, uses a small number of readily available components, and can be built for about \$10.

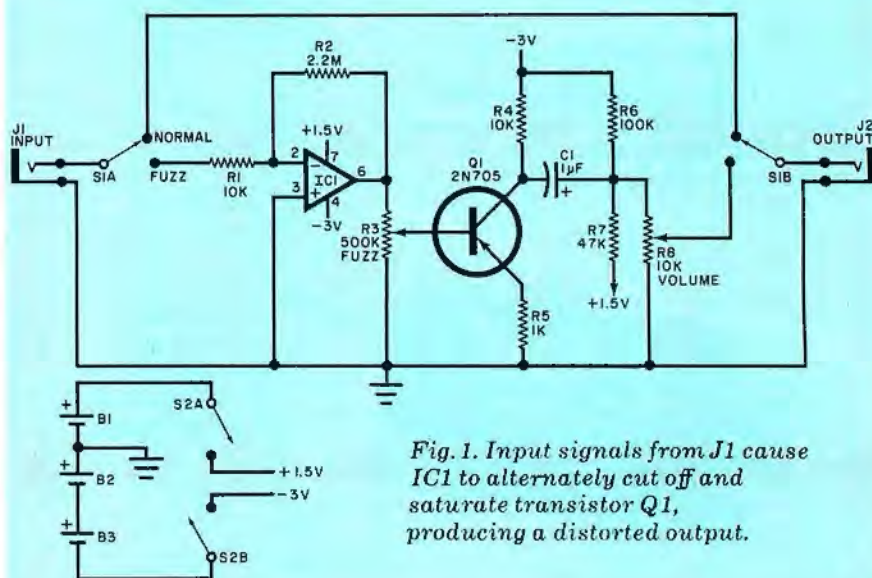


Fig. 1. Input signals from J1 cause IC1 to alternately cut off and saturate transistor Q1, producing a distorted output.

PARTS LIST

B1, B2, B3—1.5-volt AA, A, C or D cells
C1—1-µF, 16-V radial-lead electrolytic
IC1—741CV operational amplifier (Radio Shack 276-007 or equivalent)
J1, J2—¼-inch open-circuit phone jacks
Q1—General-purpose, high-beta pnp switching or audio transistor (2N705, Radio Shack RS-2005 or similar)
The following are ¼-watt, 10% tolerance fixed resistors:
R1, R4—10,000 ohms
R2—2.2 megohms
R5—1000 ohms
R6—100,000 ohms
R7—47,000 ohms

R3—500,000-ohm linear-taper potentiometer
R8—10,000-ohm linear-taper potentiometer
S1—Dpdt switch
S2—Dpst switch
Misc.—Printed circuit board, battery holders, hookup wire, suitable enclosure, knobs, pc board spacers, machine hardware, solder, etc.

Note—The following are available from BNB Kits, RD1, Box 241H, Tennent Rd., Englishtown, NJ 07726: etched and drilled pc board, #F-PC at \$3.25; complete kit of parts including etched and drilled pc board, electronic components, jacks and switches, #F-E at \$12.50. NJ residents add 5% sales tax.

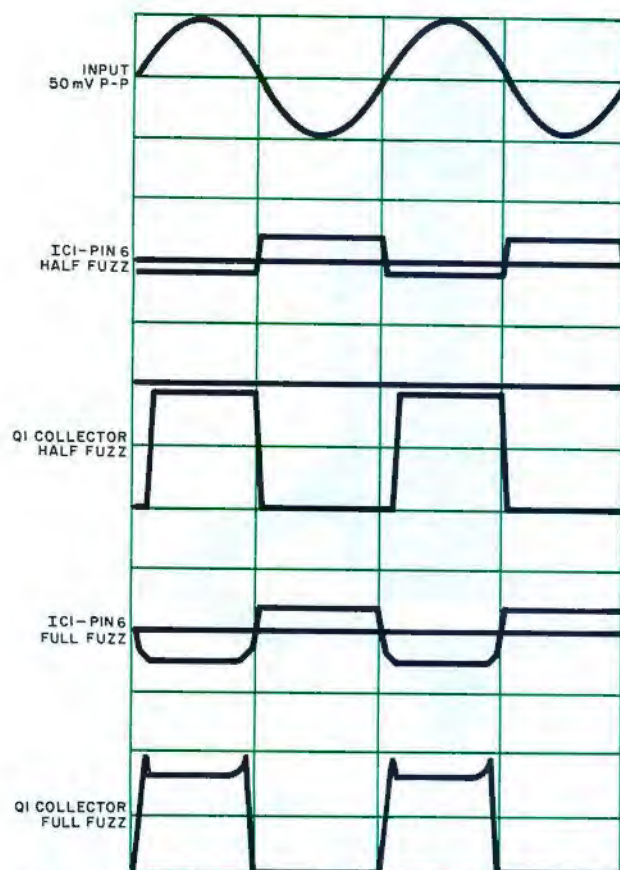


Fig. 2. Waveforms show effect of fuzz control $R3$. When it is set to pass maximum signal, the output waveform folds over and the sound is raspy.

About the Circuit. As shown in Fig. 1, input signals from the guitar pickup are routed by $S1$ to the output jack or to inverting amplifier $IC1$, a standard 741 op amp. You might notice that the power supply voltages, furnished by series-connected AA penlight batteries, are lower than those normally used with this op amp. In this application, $IC1$ is used solely to turn $Q1$ on and off. The supply voltages employed allow the op amp to saturate at lower than normal input levels to produce the desired base drive for the transistor.

An input signal of about 30 mV produces ± 1 volt at the output of $IC1$, which is applied to the base of $Q1$ through $R3$. A positive output from $IC1$ causes $Q1$ to cut off, and a negative output saturates the transistor. An ac signal will switch $Q1$ between saturation and cutoff, thus producing a square-wave output from the circuit.

With $R3$ adjusted so as to pass maximum signal to the base of $Q1$, $IC1$ forward biases the base-collector junction of the transistor as the op amp's output goes negative. When this happens, $Q1$

stops acting like an inverting switch (see Fig. 2) and passes the signal like a simple diode. The voltage at the collector then follows that at the base and, in effect, causes the signal waveform to "fold over" as shown in the bottom trace of Fig. 2. This signal is rich in harmonics and has a raspy, but mellow, sound.

Signals at the collector of $Q1$ are ac coupled by $C1$ to voltage divider $R6, R7$. Level shifting at this point presents a zero-volt signal to output level control $R8$ in the absence of an input signal. This inhibits the generation of "popping" signal transients as the fuzz box is switched in and out of the signal path. The required supply voltages (+3 and -1.5 volts) are provided by three 1.5-volt batteries. Suitable for this application are AA, A, C or D cells.

Construction. Any assembly technique is acceptable, but a printed circuit board is perhaps the easiest and neatest way to reproduce the circuit. (See Parts List for availability of pc board and kit.) Suitable etching and drilling and parts placement guides are shown in Fig. 3. After the project has been wired and is operating, it can be housed in any suitable enclosure, including the electric guitar or bass. If you decide to put it in your musical instrument, keep the batteries accessible for replacement.

Checkout and Use. Connect your guitar or bass to the input jack and your amplifier to the fuzz box's output. Rotate the instrument's output level control for maximum signal and, with $S1$ in its NORMAL position, adjust the amplifier's master volume control for a comfortable listening level. Set $R8$ (VOLUME) for $\frac{1}{3}$ rotation and $R3$ (FUZZ) for $\frac{3}{4}$ rotation. Place $S1$ in the FUZZ position and play the instrument, noting the sound produced. Rotate $R3$ fully to hear a sound with increased "bite" or raspiness.

Next, adjust $R3$ so that the wiper is at the midpoint of its travel and set the instrument's output level control for less signal until the following occurs. When a string is first plucked, a distorted output is heard. As the output level begins to decay, the distortion diminishes to the point where the instrument's sound is relatively unaltered. This is the characteristic distorted "tube" sound that inspired the original fuzz box.

Continue to experiment with different control settings. You'll doubtlessly discover many sounds that will add to your enjoyment of playing and the audience's listening pleasure. \diamond

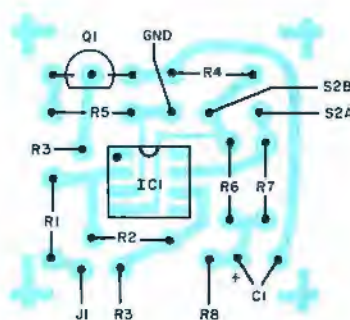
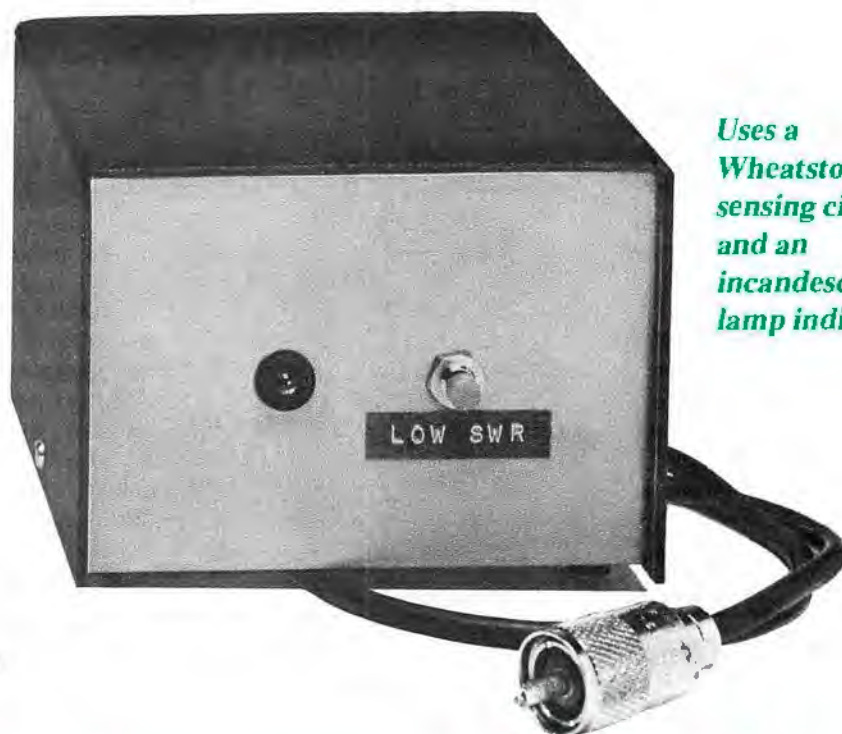


Fig. 3. Full-size etching and drilling guide for pc board is above left; component layout at right.



*Uses a
Wheatstone bridge
sensing circuit
and an
incandescent
lamp indicator.*

BY CASS LEWART

Build a Low-cost SWR TESTER

Initial adjustment of a CB antenna calls for the use of an SWR meter. However, the meter need not be left in the line after the antenna has been tuned, so most CB'ers have not felt the need to purchase one. The project presented here—an inexpensive SWR Tester—allows an operator to make periodic "good/bad" checks of his antenna system. Employing only a handful of resistors, a switch, and a small incandescent lamp, the project can be built for about \$3. The SWR Tester will not yield a numerical SWR measurement, but will tell the user whether the antenna/line

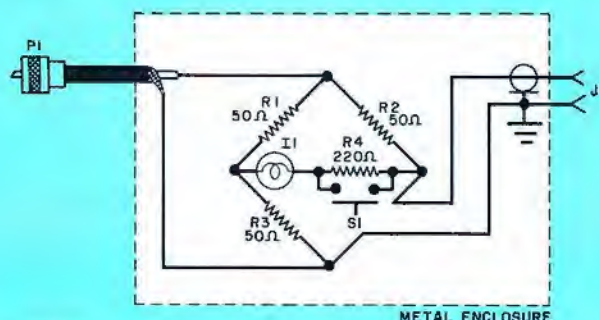
mismatch is severe enough to warrant further investigation.

About the Circuit. The schematic diagram of the SWR Tester is shown in the diagram. It is a Wheatstone bridge, one of whose arms is formed by the transmission line and antenna. The remaining three arms are 50-ohm carbon resistors. Indicator *I1*, a low-voltage incandescent lamp, current limiting resistor *R4* and pushbutton switch *S1* comprise the bridge's detector.

When an antenna having a 50-ohm resistive feedpoint impedance (the ideal

condition for maximum power transfer) is connected to jack *J1* by a length of 50-ohm coax, the impedances of the bridge arms are equal. Therefore, the bridge is balanced and no voltage drop exists across the detector. Lamp *I1* remains dark, indicating an SWR close to unity. If the antenna's feedpoint impedance deviates from the ideal 50 ohms, the bridge becomes unbalanced and a voltage drop exists across the detector.

An antenna/feedline impedance mismatch (that is, an SWR) of about 2.5:1 will produce a voltage drop across the detector sufficient to cause *I1* to glow.

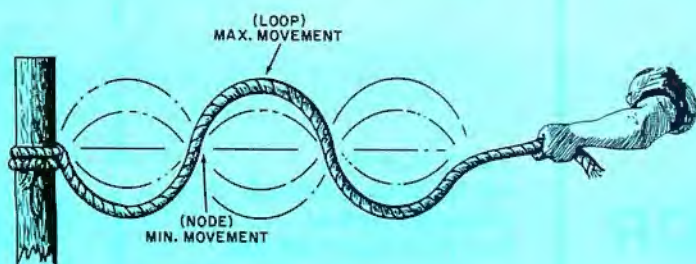


Schematic diagram of tester. The antenna/feedline combination forms the fourth leg of a Wheatstone bridge.

PARTS LIST

- J1—SO-239 coaxial connector
- I1—1.5-volt, 25-mA miniature incandescent lamp (Radio Shack 272-1139 or equivalent)
- P1—PL-259 coaxial connector
- R1, R2, R3—47- or 50-ohm, 2-watt 5% carbon composition resistor
- R4—220-ohm, 1/2-watt, 10% carbon composition resistor
- S1—Normally open pushbutton switch
- Misc.—Suitable metal utility box, ceramic standoff insulators or multi-lug terminal strip, hook-up wire, RG-58-U coaxial cable, rubber grommets, machine hardware, solder, etc.

WHAT IS SWR?



Tie a rope or string to some solid, stationary object such as a tree or post, as shown in the diagram. Grasp the free end and start waving the rope up and down. You are now generating a train of waves, much in the way that a transmitter sends waves down a transmission line.

When the wave reaches the point where the rope is anchored, there is no place for it to go so it is reflected back down the length of the rope. In this way, a pattern is formed as shown, with the loops being the points of maximum movement and the nodes the points of minimum movement of the rope. The ratio of the maximum to minimum waveform amplitude along the rope (called the Standing Wave Ratio, or SWR) in this case is 1:0, or infinity. This happens because essentially no energy is being absorbed by the wall and all is being reflected back to the driving source. This is analogous to the termination of a transmission line with an impedance that is different from that of the line. If the rope were not

tied to the poles and were free to continue to move so that the transmission of the wave could continue, there would be no wave reflection. Each point on the rope would then reach the same maximum amplitude and the SWR would be 1:1, or simply 1.0.

In electrical terms, SWR can be considered as the ratio between the antenna impedance and the CB transmitter output impedance, with the larger value being the dividend and the small value, the divisor. The closer the ratio is to 1:1, the more of the transmitter r-f goes to the antenna. Besides reducing the power output to the antenna, a high SWR can also damage the transmitter output stage by submitting it to either excessive voltage or current. Therefore, keeping the SWR close to 1.0 is very important.

The table shows the relationship between SWR and the power delivered to the antenna, assuming a nominal 4-watt output from the CB transmitter.

SWR	1.0	1.2	1.5	2.0	3.0	5.0
Reflection Loss (dB)	0.00	0.04	0.18	0.51	1.25	2.55
Antenna Power (watts)	4.00	3.97	3.84	3.56	3.00	2.22

The higher the SWR becomes, the brighter *I1* will glow. Closing normally open *S1* increases the bridge detector's sensitivity so that *I1* begins to glow at an SWR of about 1.5:1. Note that this causes *R4* to be bypassed, removing the resistor's protective current limiting action from the detector circuit. If *S1* is closed when a high SWR exists on the line and *I1* is glowing, the lamp might burn out.

The bridge presents a 50-ohm impedance to the transceiver's antenna output when a 50-ohm antenna is connected to coaxial connector *J1*. However, there is a 6-dB power loss associated with inserting the SWR Tester between the rig and the antenna. The project is not designed for continuous monitoring of the SWR during communications, and should be removed from the signal path after tests have been completed. This can be accomplished by either physical-

ly disconnecting the SWR Tester or the installation of a ceramic DPDT switch inside the project's enclosure to bypass the bridge circuitry.

Construction. The circuitry of the SWR Tester is very simple, and point-to-point wiring is suitable. Solder lugs mounted on ceramic standoff insulators make ideal circuit tie points, but the standoffs might be hard to find. If you can't procure them, use a multi-lug terminal strip instead.

Mount the standoffs, switch, and coaxial jack in a small metal utility box. Drill holes for the indicator lamp and RG-58-U cable. Insert grommets into these holes, mount the indicator lamp, and pass one end of an 18-to-36-inch (45.7-to-91.4-cm) length of coax through the wall of the enclosure. Form a simple loop knot to act as a strain relief. Then remove 1¼" (3.2 cm) of the outer in-

sulating jacket at the end of the cable inside the utility box. Comb out the braid, expose a short length of the inner conductor, and wire the circuit as per the schematic diagram. Terminate the other end of the cable with *P1*, a PL-259 coaxial connector.

Checkout and Use. Attach *P1* to the transceiver's antenna output jack. Prepare a dummy load by terminating a PL-259 with a 150-ohm, 2-watt carbon composition resistor and attach it to jack *J1*. Tune the transceiver's channel selector to channel 13, or to channel 20 if the radio has 40-channel capability. Place the mode switch in the AM position if you are using an AM/SSB rig. Then key the transceiver's push-to-talk switch.

Lamp *I1* will glow brightly. Note its brightness, and repeat the procedure on the other channels. If the rig's output remains relatively constant across the band, *I1*'s brightness will not vary from one channel to the next. Next, replace the 150-ohm resistive dummy load with a 100-ohm component. Key the transmitter. With *S1* open, *I1* will be dark. Closing *S1* will cause the lamp to glow.

The SWR Tester is now ready for use. Connect the coaxial feedline from the antenna to jack *J1*. If the antenna has been properly tuned and is in good working order, the lamp will remain dark when *S1* is open and the transceiver is keyed. The indicator might glow when *S1* is closed, especially when the channel selector is set to either end of the band and the antenna has been tuned to the center channel. This is normal because it is difficult to maintain a close impedance match over a wide band of frequencies. Short mobile whips with large loading coils are subject to such bandwidth limitations almost as a matter of course.

If the indicator glows when *S1* is open no matter which channel is selected, you should inspect the antenna and feedline for oxidized or corroded connections, clean metal-to-metal contact between the ground plane (vehicle body) and antenna base, etc. If no suspicious conditions are discovered, retune the antenna using an SWR meter and/or a field strength meter.

After you have retuned the antenna or completed your SWR tests, remove the project from the signal path—either physically or by means of a bypass switch. Otherwise, signals passing from the transceiver to the antenna (and vice versa) will be substantially attenuated. ◇

Micro- PROCESSOR MICROCOURSE

PART 4. PIP-2 AN ULTRA-SIMPLE EDUCATIONAL MICROPROCESSOR.

IN Part 3 of this series (May, 1978), we learned about semiconductor memories and how three-state logic allows data transfer over a bidirectional data bus. We also looked at the basic organization of a microprocessor.

This month we're going to meet PIP-2, a very simple, 4-bit educational microprocessor. Though PIP-2 is not as powerful as the 8080, Z80, 6502 and other real-world microprocessors, it illustrates some of the more important operating features of microprocessors.

Introducing PIP-2. PIP is an acronym for Programmable Instruction Processor. PIP-2 is a simplified successor to PIP-1, an educational computer described in detail in *Understanding Digital Computers*, a new book published by Radio Shack.

While PIP-2 is simple, it has many of the elements of a sophisticated microprocessor. For example, PIP-2 contains a built-in program memory—so it really qualifies as a *microcomputer*. Since it also contains a microprogrammable control ROM, this means that its instruction set can be revised, or replaced, by entirely new instructions, as we will see in Part 5 of this series.

PIP-2's Organization. A block diagram of the major components of PIP-2 is shown in Fig. 1. As you can see, PIP-2 is a bus-organized microprocessor. All of its sections are connected to a 4-bit bidirectional bus which permits data and memory addresses to be transferred from one section to one or more other sections connected to this bus.

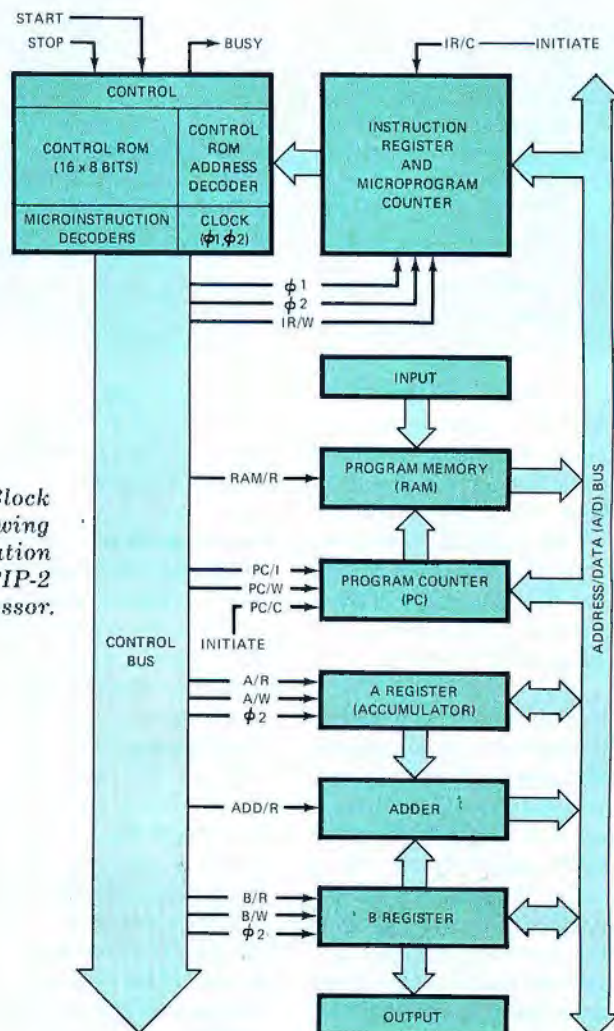
Remember from Part 3 that only *one* section can read data onto a bidirection-

al bus at any one time. PIP-2 meets this operating restriction by employing three-state outputs on all sections designed to read data onto the bus. This isolates the output of those sections from the bus

until they are activated (one at a time) by an appropriate enable signal from PIP-2's control section.

Let's now take a look at each of the sections in PIP-2.

Fig. 1. Block diagram showing organization of the PIP-2 microprocessor.



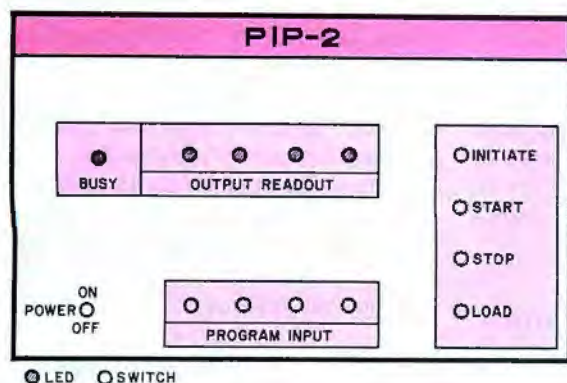


Fig. 2. Front-panel arrangement to facilitate operation of PIP-2.

Input. A row of four toggle switches, a LOAD switch and an INITIATE switch comprise PIP-2's INPUT. All these switches are shown in Fig. 2, a front-panel arrangement that allows PIP-2 to be used like a microcomputer.

Applying power to PIP-2 automatically clears the A and B registers, the program counter and the program memory to all 0's. This permits a program to be loaded into the program memory by simply switching in a binary instruction or data word and pressing the LOAD switch.

Up to sixteen 4-bit instructions and data words can be loaded into PIP-2's program memory. After the program is loaded, the program counter is cleared to 0000 by pressing the INITIATE switch. This returns the program counter to the first memory address in the program memory in preparation for running the program.

Program Memory. This is a 64-bit read/write memory (RAM) organized as sixteen 4-bit words or "nibbles." The RAM has a three-state output to keep its instructions and data isolated from the address data bus until they're needed.

The program memory has a single control input, RAM/R (R = read). When RAM/R is low, the three-state output is enabled, and the RAM reads the word addressed by the program counter onto the address data bus. When RAM/R is high, instructions and data can be loaded into the RAM.

Program Counter. This is a 4-bit binary counter. PIP-1 and many real microprocessors have a special memory address register that saves the contents of the program counter until it's time to advance to the next memory address. In PIP-2, the program counter doubles as a memory address register.

The program counter has three control inputs. A "low" that's supplied to PC/C by pressing the INITIATE switch clears the counter to 0000. The rising edge of a pulse applied to PC/I increments the program counter to the next

higher count. A low at PC/W (W = write) writes any data on the address data bus into the program counter. This is a valuable feature since it means the program counter can branch to any address in the program memory.

A and B Registers. These are standard 4-bit data registers with three-state outputs. Each has two control inputs and a clock input ($\phi 2$).

When A/R or B/R is low, data is read from the selected register onto the address/data bus. When A/W or B/W is low, any data on the address/data bus is written into the selected register when the next clock pulse ($\phi 2$) arrives.

Adder. This is a 4-bit combinational logic circuit that continually sums the contents of the A and B registers. The sum is isolated from the address/data bus by a three-state buffer. When ADD/R is low, the buffer is enabled and the sum is placed on the bus.

Output. PIP-2's output consists of four light emitting diodes (LED's) that continually show the contents of the B register. It's possible, of course, to connect external devices in place of the LED's. A 4-line to 16-line decoder, for example, would permit PIP-2 to control any one of up to sixteen external devices.

Control. This is the electronic nerve center of PIP-2. Control fetches instructions from the program memory and

executes them one by one under the perfectly synchronized control of timing signals ($\phi 1$ and $\phi 2$) produced by the clock.

Control consists of a 128-bit ROM organized as sixteen 8-bit bytes, an address decoder, several microinstruction decoders and a two-phase clock. PIP-2's instruction register doubles as a microprogram counter and is so closely associated with control that it can be considered part of it.

In the next installment, we'll look at a block diagram of control and study its operation in detail. For now, suffice it to say that control's ROM contains a sequence of from one to five microinstructions for each of the various micro-routines necessary to execute PIP-2's six instructions. As you'll recall from Part 3, individual microinstructions implement simple operations such as data transfers from one register to another, etc.

PIP-2's Instruction Set. PIP-2 can process six separate instructions. Each instruction is identified for humans by a type of shorthand called a *mnemonic* (memory aid) and for PIP-2 by a 4-bit nibble called an operation code or in simple terms an *op-code*.

Some of the instructions require only one program memory address, while others are followed by a data word. These latter instructions require two program memory addresses and are called memory reference instructions. For example,

```
0001 (LDA)
1111 (data)
```

is the format for a memory reference instruction that loads the A register (LDA) with the data word 1111.

Shown in the box below is a table that summarizes PIP-2's instructions set. These instructions are so simple that they really need no further explanation.

PIP-2's INSTRUCTION SET			
Mnemonic	Op-Code	Nibbles	Operation
NOP	1111	1	no operation.
LDA (nibble)	0001 (xxxx)	2	load A with next nibble.
ADD	0101	1	add A+B; store sum in A.
JMP (address)	1000 (xxxx)	2	jump to address in next nibble.
MOV	1011	1	move A into B; save A.
HLT	1110	1	halt the microprocessor.

It will be easier to apply them in actual programs, however, if we know something about how and why they're used. Therefore let's discuss the instructions one by one.

NOP. Pronounced "no-op," this is a do-nothing instruction with several valuable applications. You can use a NOP or two to reserve space in a program for an instruction or two you might want to add later. And you can use NOP's to replace instructions you remove from a program without rewriting the program. Finally, you can use NOP's to add a predictable time delay to a program. This is handy for calibrating a program that loops through a cycle of instructions again and again to act like a timer.

LDA. This memory reference instruction (load A) loads the A register with the data nibble in the next program memory address. It is used to temporarily store a nibble for addition or later transfer to the output or program counter.

ADD. This single-step instruction initiates a string of five microinstructions that *adds* the contents of the A and B registers and place the sum in the A register. It is used for ordinary addition, and to increment the nibble in the A register by some specified number (often 1). Incidentally, ADD uses the A register like the accumulator register found in real microprocessors.

JMP. This (jump) is a very powerful instruction that orders the program counter to branch (or jump) to the address in the program memory specified in the following nibble. JMP is used to set up a *loop*, a program or section of a program that continues to execute again and again until PIP-2 is halted by pressing its STOP button.

MOV. This register-transfer instruction has several applications. As an output instruction, it allows PIP-2's operator to see the contents of the A register on the LED readout (output). It also allows you to accomplish the equivalent of a LDB (load B) instruction by preceeding it with LDA (load A). And, it lets you double a number by following it with an ADD.

HLT. This instruction (halt) is placed at the end of all PIP-2 programs. It disables the clock in the control section, thus preventing PIP-2 from executing any additional instructions.

In the next part of the course, we'll examine the microroutines for each of these instructions in detail. We'll also learn how to add new instructions by changing the microinstructions in con-

trol's ROM. Meanwhile, let's learn how to program PIP-2.

How to Program. Let's write a simple program for PIP-2 that continually increments the number in the A register by one and displays the updated count on the LED readout of the output. Here's the program:

Program	
Memory Address	Mnemonics/Data
0000	LDA
0001	0001
0010	ADD
0011	MOV
0100	JMP
0101	0000
0110	HLT

It's easy to see how this program works. When PIP-2 is started, both the A and B registers are cleared to 0000. This means that the first three instructions load 0001 into A, add A to B and store the sum (0001) in both A and B. JMP loops the program back to line 0000 for another cycle. LDA replaces the contents of A with 0001 first. Register B also contains 0001 so ADD gives 0010. The sum, 0010, is moved into B and displayed on the readout.

Again, JMP loops the program back to line 0000 and the process continues. The result is that the readout flashes a binary count of 0000 to 1111 and continues repeatedly until PIP-2 is halted.

As you can see, this program is nothing more than a software version of an ordinary 4-bit counter. That alone is not very impressive since PIP-2 already contains two such counters in its hardware, the program counter and instruction register.

What's significant is that this simple program can be easily modified to implement *any* count increment from 0000 to 1111 by simply changing the data nibble following LDA! While this can be accomplished with some relatively simple hardware, PIP-2 performs the task after only a few seconds of software modification. This nicely illustrates the amazing versatility of using a microprocessor to simulate many different hardware functions with the help of software.

Running the Program. The simple counter program we've been discussing is called a *source program* since it's written using the mnemonics of the various instructions. Before it can be loaded into PIP-2's program memory, it must be converted to an *object program*.

An object program is written using the binary numbers a microprocessor understands. Sometimes it's called a *machine language program*. All that's necessary to generate the object program for our software counter routine is to substitute the appropriate op-codes for the mnemonics in the source program with the help of the table showing PIP-2's instruction set. Here's the machine language result:

Address	Source Program	Object Program
0000	LDA	0001
0001	0001	0001
0010	ADD	0101
0011	MOV	1011
0100	JMP	1000
0101	0000	0000
0110	HLT	1110

After the object program is compiled, it's a simple matter to load it into PIP-2's program memory. First, the power switch is turned on. This automatically clears all of the program memory, registers and counters to all 0's. Then the first object code nibble in the program (0001) is switched in via the front panel switches (a switch is 0 in the down position and 1 in the up position) and the LOAD switch is pressed. This action loads the nibble 0001 into the 0000 address of the program memory and automatically advances the program counter to the next address.

The remaining nibbles are loaded one by one until they are all stored sequentially in the program memory. Then the INITIATE switch is pressed to return the program counter to the 0000 address of the program memory.

Now all that remains is to press START. This causes control to fetch the first instruction from the program memory, load it into the instruction register, decode it and execute it. The program is processed like this a step at a time as the output displays the updated contents of the B register.

Incidentally, if the clock speed is more than about a hundred Hz, the count displayed on the readout will blur into a continuous 1111. Since the clock of most real microprocessors runs at a MHz or more, time delay loops must be added to their programs intended to display data to be viewed by an operator.

Other PIP-2 Programs. Though PIP-2's instruction set is very primitive, it's possible to write a number of differ-

ent programs with it. Here, for example, is a source program that adds two numbers and displays their sum:

```
LDA
(first number)
MOV
LDA
(second number)
ADD
MOV
HLT
```

Here's a source program that doubles a number:

```
LDA
(number)
MOV
ADD
HLT
```

And here's a program that counts by two's:

```
LDA
0002
ADD
MOV
JMP
0000
HLT
```

Programming Real Microprocessors. Real microprocessors have dozens of instructions in their instruction sets. A typical microprocessor such as the 6800 or 8080 has instructions that can accomplish any of these tasks:

- Move data and addresses between registers.
- Shift and rotate the bits in a data word.
- Perform various arithmetic and logical operations.
- Branch conditionally or unconditionally to any part of a program or to a sub-routine.
- Make various logical comparisons.
- Increment or decrement the contents of a register or memory address.

Real microprocessors also have special instructions that may be unique to a particular family of microprocessors. For example, some microprocessors have various instructions for accepting data from outside circuits. Others have built-in decimal arithmetic capability.

Programming real microprocessors can be both tedious and time consuming, but most people can learn to write simple programs with a little practice and some hands-on experience with a microprocessor using a keyboard (best) or toggle switch (OK) input. Of course, many microprocessor programs have been published in books and articles; and as time goes by, the number of available programs will multiply. ◇



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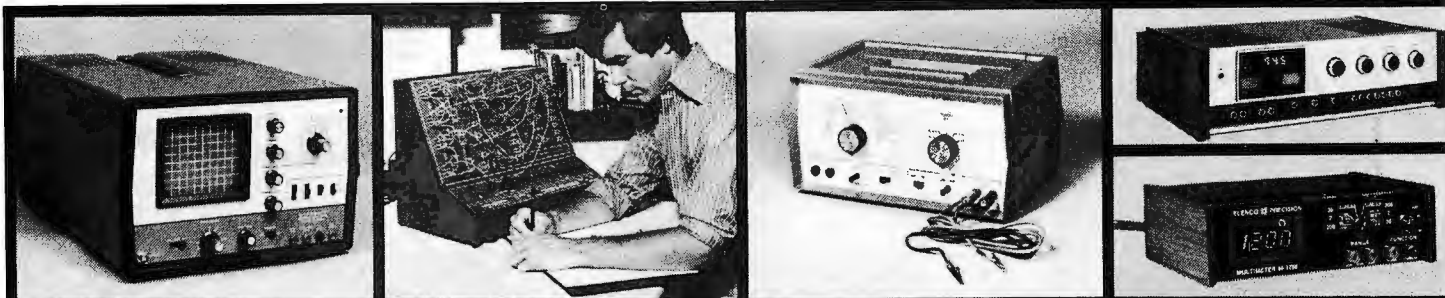
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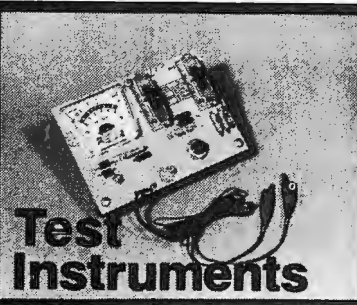
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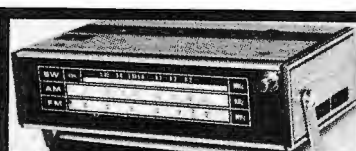
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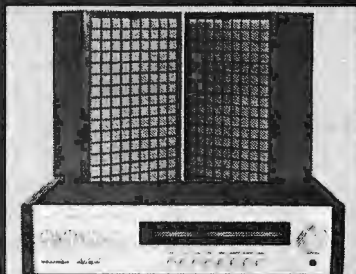
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Focus On Speaker Systems

BY IVAN BERGER, Senior Editor

*A buying guide to loudspeaker systems,
including model comparisons.*

I. UNDERSTANDING THE SPECIFICATIONS

THE SPECIFICATIONS on the following pages cover the vast majority of high-quality speaker systems available in the U.S. and though specs alone can't tell you what a speaker sounds like, they can serve as a preliminary screening guide to help you narrow down your list of speakers to the few most likely to suit your requirements. Since there are probably more manufacturers of speakers than of any other high-fidelity component, that can save you a lot of time.

Nationally Advertised Value.

The prices listed in our guide are those that are nationally advertised by the manufacturers. But dealers in your area may offer lower ones—check before buying. The fact that discounts are available on some models means that you needn't restrict your list of possibilities to those whose nominal price is within your budget—models listed at up to one-third more than your budget figure may actually be available in your price range. On the other hand, don't be too surprised if some of the prices listed here have risen by the time you get to an audio dealer. Speaker manufacturers' costs go up, too, and fluctuations in foreign-exchange rates can play havoc with the cost of imports.

When setting your speaker budget, don't stint. Speakers have a greater effect on your system's overall sound than any other component, so it pays to invest substantially in them. But if two speakers sound absolutely *equal* to you (they'll rarely sound absolutely *alike*), feel free to buy the less expensive ones if all else meets your needs.

Enclosure Types. Like most technical specifications, this one is sometimes over-emphasized in sales literature. In most cases today, it's possible to build equally good-sounding—and even similar-sounding—systems with any enclosure type. But every speaker must have some sort of baffle or enclosure to keep the waves that radiate from the back of the speaker from mixing uncontrollably with the front waves. Since the front and rear waves are out of phase, uncontrolled mixing would allow them to neutralize each other, cancelling the sound. In practice, this only occurs at the low frequencies, where the wave lengths are longer than the distance around the baffle. For this reason, enclosure design has most effect on the bass frequencies.

Acoustic-suspension or "air-suspension" enclosures are small, sealed boxes whose trapped air serves as the spring for otherwise floppy speakers. Acoustic-suspension speakers have been most popular for years because they can deliver clean, deep bass from comparatively small enclosures. The drawback of acoustic-suspension systems has been their low efficiency: all else being equal, it takes more power to drive an acoustic-suspension speaker to a given output level than it takes to drive most other systems.

The bass-reflex system, unlike the air-suspension type, has an opening or "port" through which the low-frequency driver's back wave can escape to the front. With careful design, this wave can be made to emerge in-phase with the woofer's front wave, just at the frequencies where the woofer needs

help most. You'll find more and more bass-reflex systems among the newer models, since the characteristics of such systems can now be more precisely formulated than a decade ago. This allows designers to eliminate boomy resonances that formerly characterized some reflex systems. And since the back wave is used, not wasted, reflex speakers tend to have higher efficiency than air-suspension types.

Passive radiators (also known as "drone cones" or "auxiliary bass radiators") are sometimes used in place of ordinary open vents. At least one manufacturer therefore calls them "vent substitutes."

Several of the formulas for vented-speaker designs involve the deliberate acceptance of small response irregularities, which can easily be corrected with external equalizers, in exchange for better performance in areas where equalizers cannot help. The equalizer must be carefully matched to the speaker in such cases, and several speakers which come with such external equalizers are listed here. Not all reflex systems offer high efficiency, though. The formulas that now govern reflex system design allow a trade-off between efficiency, deep bass, and enclosure size. Designers may choose to give you more of one in return for less of another.

"Transmission-line" or "acoustic-labyrinth" designs are basically long, padded tubes, folded back and forth to fit into a box of a convenient-size. This is a very clean way to absorb the back wave of the speaker, but its absorption means it cannot contribute to efficien-

cy. Some labyrinths (only the closed type are true transmission lines) therefore are open-ended, tuned so that the back wave emerges in phase at a low frequency where its contribution will be useful.

Horn speakers, today a rarity among woofer enclosures (though horn tweeters are still common) have the highest efficiency of any speaker, and gain low distortion by keeping cone movement small. But their mouths must be immense for good bass output, so the most common type is the "corner horn," which uses the walls of a room corner as part of the horn. Such speakers are, however, expensive—the horn must be folded in upon itself like the labyrinth, making the enclosure complicated to build—and still large. And they can only be used in rooms having suitable corners. (Not all corner speakers are horns, though—and placing any speaker in a corner will reinforce bass response.)

Open baffles also work, but they must be large in order to control bass cancellation. The Transar and many full-range electrostatic and planar speakers use such baffles.

Woofer Size and Type. It's generally believed that the bigger the woofer, the lower the bass. But that's only true if the enclosure is made larger, too. Larger woofers do have lower resonant frequencies when measured in free air. But once mounted in an enclosure, a larger woofer will (all else being equal) exhibit a higher resonant frequency than a smaller one mounted in the same box! The larger cone moves more air for the same degree of cone excursion. Moving more air into a box of a given size raises the air pressure in the box, stiffening the "air spring" the driver is pushing against. Since the resonant frequency depends on both the mass (of cone and air) and the compliance, or springiness, of the air and the driver suspension, the reduction in air compliance raises the system's resonance more than the increased driver mass lowers it.

Within a given enclosure, then, a larger woofer (which moves more air for a given cone excursion) will produce bass more efficiently—but a

smaller woofer will produce deeper bass frequencies, though weaker in output. Enlarging the enclosure lets the larger woofer deliver deep bass, too, and more efficiently. But the system then takes up more space and costs more. In short, don't expect woofer size alone to make one system deliver deeper bass than another.

Most woofers are standard cone drivers, regardless of enclosure type. Even here, however, there are some variations. Many makers now use woofers covered or impregnated with plastics (commonly Bextrene) or carbon fibres, to stiffen the woofer and increase its internal damping, both of which reduce cone breakup distortion.

Some manufacturers use very shallow woofers, to minimize the phase differences between woofer and tweeter. Others stagger their drivers, so that the tweeter's mouth is far behind the woofer's. Both techniques put the woofer and tweeter voice coils in the same plane, allowing the output from both drivers to reach the listener at precisely the same time, not a tiny fraction of a second apart (provided the crossover networks dividing the sound between woofer and tweeter do not add time delay problems of their own). Opinions are divided as to whether or not phase-coherent design audibly improves the sound, but there's no question that phase-coherence can't degrade it.

Planar woofers, such as the various electrostatics and the "flat-panel" speakers driven by regular or distributed voice coils, are usually in open baffles. Either the baffles or the speaker driving elements (preferably the latter) must be large to deliver sound power at low frequencies. In practice, this means that such speakers often require additional subwoofers for the very low bass—note the rated frequency-response figures in our chart.

Other Driver Sizes and Types. Most speaker systems use at least two separate drivers—a massive woofer for the lows and a small tweeter for the highs—and many use 3 or more driver sizes. This is because each end of the frequency spectrum imposes opposite requirements on a driver. Bass response requires a large driver that can

move a lot of air and handle a great deal of power. Treble response requires as light a driver as possible (which also improves transient response). In addition, it requires a small driver, for broad, even dispersion. (Dispersion is a function of the ratio between driver size and sound wavelength.) Midrange dispersion is rarely a problem, especially in speakers with separate midrange drivers. So high-frequency dispersion—as evidenced by tweeter size—is probably the most important specification in this column.

Dome tweeters have no better (or worse) dispersion than cone types of equal size. However, dome tweeters have larger voice coils, which allows more power-handling capacity—and also increases the size and cost of the magnet that must be used with them.

Electrostatic tweeters tend to have limited excursion, which makes it easier to give them good transient response, but also means they must be larger than cone types, which limits their dispersion. For that reason, most electrostatic tweeters use several tweeter elements, angled apart to cover a wider sound field. (Some nonelectrostatic tweeters do this, too.)

Horn tweeters allow a small, light diaphragm with good transient response to radiate appreciable power efficiently without breaking up. The driving diaphragm is usually a dome or flat diaphragm with a conventional voice coil, but more and more horn tweeters use piezoelectric drivers, solid-state devices that produce sounds by flexing in response to signal voltages. But designing horns for good high-frequency dispersion is hard. The approaches taken include the use of multi-cellular horns, and of "acoustic-lens" louvers at the horn mouth.

Crossover Point. Dividing the frequency range between several different drivers requires that each driver handle only that part of the range that it's designed for. Electrical "crossover networks" ensure that each driver get only its proper range, and that response slopes off at those frequencies that another driver should handle. In practice, the frequency ranges of ad-

Focus On Speaker Systems Continued

joining drivers overlap, and there is a point—the crossover frequency—where each is contributing half the total radiated sound. The more divisions, the more such frequencies: a two-way (woofer-tweeter) system has just one crossover point, a three-way (woofer-midrange-tweeter) system has two crossovers, and so on.

Impedance. A speaker's impedance changes with frequency. Its rated impedance is usually the lowest impedance it will reach at any point within its frequency range (generally, the mid-bass region). Usually given as 4, 8 or 16 ohms, impedance is mainly important when you intend to connect more than one pair of speakers to the same amplifier. Many amplifier circuits can be damaged by the 2-ohm impedance which results from operating two 4-ohm speakers in parallel. Unless you know your amplifier can handle it, buy higher-impedance speaker systems for multiple-speaker installations.

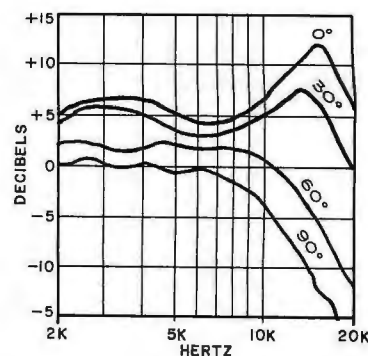
Frequency Response. This specification is useful, but only as a rough guide: measurement standards vary, and a speaker's measured response will vary with the microphone position and the space surrounding the speaker when it's tested. The specified response might be the on-axis response in an anechoic chamber, the on-axis response in a reverberant chamber (which would show more bass—how much more depending on the chamber

size and shape), or a total-radiated-power response taken in a reverberant room but including both on-axis and off-axis measurements.

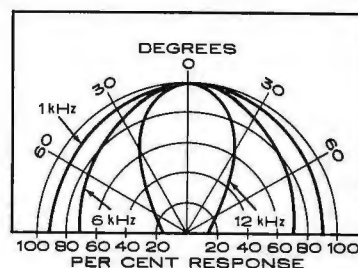
Frequency response figures which specify how many decibels (dB) the sound varies over the indicated range are more meaningful than those which simply state the frequencies spanned. You know that a speaker that is within ± 6 dB from 30 to 18,000 Hz has fairly substantial bass response, but a speaker whose response is stated only as an unqualified "30 to 18,000" could be considerably more than 6 dB down at 30 Hz (though it could be less than 6 dB down, too). Without the qualification in dB, you just can't tell.

Sensitivity and Minimum Recommended Power. These useful specifications help determine how much amplifier power you need to drive the speaker system satisfactorily. (Remember that, when driving two speakers, each gets about half the amplifier power, so a "20-watt" minimum means 20 watts per channel.)

Sensitivity (which is a measure of efficiency) is usually stated in terms of sound output from a 1-watt signal measured at a 1-meter distance. For example, a signal that delivers 92 dB SPL (sound pressure level) from a 1-watt signal will require 3 dB less power for a given output than one which delivers 89 dB from the same watt. Thus, the more sensitive (more efficient) speaker can be used with an amplifier half as



Dispersion can be shown by superimposing frequency-response graphs taken at several angles (above) or as polar plots for several frequencies (below).



powerful as the 89-dB speaker would require. The catch, though, is that the rating varies according to the frequency components of the test signal used. Therefore, the manufacturer's minimum power recommendation should be given at least as much weight as the sensitivity figure.

E-V Interface: B has matching equalizer, passive radiator.



Technics SB 6000A has stepped-back drivers for phase correction and ducted port.

AR-15 air suspension system with dome tweeter.



Power-handling Capacity. This tells you both how much power the speaker can safely accept. Since this specification is not rigidly defined, you should use it only as a rough guideline.

We've distinguished, where possible, between those power-handling ratings that specify momentary peak input power and those that specify continuous power capacity. However, that still leaves open the question of how long a signal of that power is safe in either case, and what the frequency components of the test signals were. In general, it's safe to use an amplifier whose continuous-power rating is the same as or a little larger than the speaker's, or one-half the speaker's peak power rating. But you can use amplifiers with higher power if you're careful not to drop the tonearm onto the groove with the volume control well up, or to plug and unplug signal sources while the amplifier is on, either of which can create speaker-blowing transients on almost any system. You can also use a high-power amplifier if you don't play your system so loud it goes into audible distortion.

If you combine the maximum power figure with the sensitivity rating, you can tell how loud the speaker can be safely played. Since 20 watts is 13 dB above one watt, a speaker with a power-handling capacity of 30 watts and a sensitivity figure of 93 dB for 1 watt input can play at levels of up to 106 dB ($93 + 13$ dB) with some presumption of speaker safety. That is probably loud enough for most classical listeners, but not for the truly dedicated rock listener, who would probably prefer a limit of 110-115 dB.

Still, check the speaker at your preferred listening level before buying it. The figures tell you only how loud the speaker can play without damage—not how loud it can play without audible distortion.

Level Controls. The sound of most speakers can be altered somewhat to account for listener preferences as well as the acoustics of the listening room and the speakers' location therein by altering the high-to-low-frequency balance. This usually requires at least a tweeter level control, and may also

involve additional controls for the mid-range and other drivers. (Woofer controls are almost unheard-of.)

The more such controls there are, and the more continuous their adjustment (as opposed to simple two- or three-position switches), the more precisely the speakers' frequency balance can be adjusted. But the more adjustments there are, the harder you'll have to work to get it just the way you want. Incidentally, tweeter-level settings labelled "flat" or "normal" are just recommendations—alter them if you feel that it makes an improvement.

Dimensions and Weight. These have little to do with the sound of a speaker (save that, all else being equal—which rarely occurs—bigger cabinets permit lower bass with fewer trade-offs). But they do help determine how well a speaker will fit into your home. Dimensions are most important, of course, if you plan to locate your speaker systems on bookshelves. And for shelf mounting, weight is important, too. Make sure your shelf can handle any speaker you plan to put on it. ◇

II. UNDERSTANDING WHAT YOU HEAR

THE SPECIFICATION sheet for a speaker system tells the buyer less about the system's sound than do the similar sheets for other audio components. Thus, the speaker buyer is

forced to rely heavily on the judgment of his own ears—superbly sensitive instruments, but not very precisely calibrated ones.

The art of buying a good speaker

must therefore begin with training our ears and minds to appreciate and understand what we are hearing. Untrained, it is too easy to fall under the seductive spell of a speaker that

Powered Advent has amplifier inside rear panel.



JBL L212 has mid/high-frequency "satellites" and common bass module.



Klipschorn folded-horn system.



Focus On Speaker Systems Continued

makes one type of program material sound startlingly real only to find its sound inadequate for those types of music you listen to most often. The sound you hear in one acoustic environment is likely to be very different in another listening room, too. There are no perfect speakers. But to the knowledgeable ears, the least imperfect speaker is the one which reproduces recorded sound most realistically, imposing the least possible coloration on that sound.

Assessing realism is, however, difficult. If you attend live concerts of acoustical—not electrical—instruments, you can use them to sharpen your listening judgements. Before shopping for a speaker, attend a concert or two. Close your eyes and analyze the sound you hear, attempting to sum up verbally the differences between this sound and the sound of the same music played at home. The verbal summation is important—words are easier to remember precisely than are subtle differences in sound.

Rock concerts are less useful training for the ear, because rock records rarely attempt to reproduce the concert sound. Instead, rock performances strive to reproduce on stage the sonic experiences that are so easily achieved in the recording studio. Besides, the sound you hear from electrically amplified performances is the sound of the amplifiers and speakers used. Recordings are usually made by direct pickup from the instruments

themselves, rather than by microphones aimed at the speakers you'd hear at a concert.

Your Own Tests. In an audio dealer's store, intelligent listening can quickly screen out the most blatantly colored or limited speaker systems. Listen to as many types of program material as you can, but with special emphasis on the kinds of music you will listen to at home. Any speaker which seems to lack highs or lows on all recordings should be rejected. The ear is easily fooled, however, since many colorations sound quite pleasing—on some material. For instance, listen to whether the bass seems rich and full and whether it is rich and full on many different notes. Or does it lend all such notes the same pitch, which is a sign of uncontrolled bass resonance? (Note, too, that below the resonant frequency, speaker output drops off dramatically.) Make sure the musical notes you hear are the ones being played, as well. On a descending passage of bass notes, for example, the fundamental tone should keep descending, not reach a plateau and stop. Some speakers falsify bass by "doubling," delivering a distorted overtone of notes below a real low-frequency limit. In this case, a distorted 60-Hz note, may be heard when a clean 30 Hz is called for. If you could play a sweep-frequency record through such loudspeakers, you would hear the sound fade cleanly as the frequency

lowered, then come back at higher volume with higher pitch. A good speaker will simply fade out below its low-frequency cutoff. It's always better to miss a few rarely recorded bass tones that are there than to muddy the sound output with tones that weren't recorded to begin with.

Test reports are a help, of course—even reports on speakers you do not intend to buy. Listen to speakers about which you have read reports, and try to correlate what you hear with what the tester heard and measured. Do this for several speakers. This will help you differentiate various speaker deficiencies and virtues.

While frequency-response specifications tell you comparatively little about a speaker, frequency-response *graphs*—whether in specification sheets or test reports—tell you a great deal. Minor squiggles can be ignored since all speakers have them (though some speaker specification sheets smooth out curves for public consumption). In your mind, however, shade in the spaces between the response curve and the reference-level chart line. The audibility of response deviations is roughly proportional to this mentally shaded area. Broad, shallow bulges and dips will be plainly audible. So will sharp but high-amplitude resonances. However, resonant peaks and dips that are both sharp *and* short will not greatly affect the speaker's sound.

Observe, too, at what frequency extremes response begins to drop off,

B.E.S. Geostatic's dipole planar drivers radiate from both sides.



H.H. Scott Pro-100 also reflects sound from ceiling.



Heil AMT tweeter squeezes air instead of pushing it.



and how fast it drops. At the bass end, look for a speaker that rolls off smoothly, rather than one which exhibits an exaggerated response hump just above the roll-off point.

Teach yourself also to recognize the effects of room acoustics on speaker demonstrations. Bear in mind that if the room you'll listen in at home has a greater percentage of hard surfaces than the store's listening room, you'll hear more highs at home. If your room

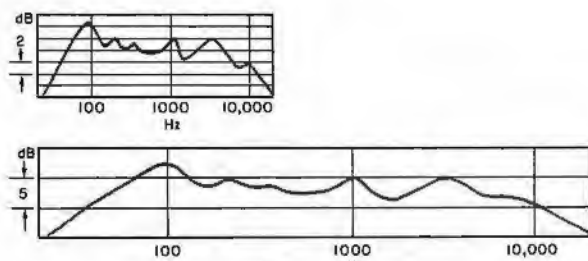
A heavily upholstered room or a turned-down tweeter control can help correct for a speaker whose high-frequency response is exaggerated, but still smooth. It cannot correct, however, for shrillness caused by peaks within the treble region. One can only eliminate these by turning down the treble enough to lose the desired highs as well. Sometimes, though, an equalizer can help here. Similarly, one cannot count on a room that is more "live"

corner on one side of the room will be farthest from it at the other. This gives each pair of speaker systems demonstrated a roughly equal chance.

Long listening sessions lead to listener fatigue, and consequent errors of judgement. So do not assume that you'll be able to pick the perfect speaker (for you) in one visit to a dealer. Take your time; limit your listening experience. You're making a substantial investment to last for many years.

Be sure not to try to compare three or more systems at once. Your sound "memory" won't be good enough. To truly discern the difference between speakers, you must compare two pairs at a time. When you have chosen the better pair, you then may compare them to a third set.

The speakers you're comparing must be *precisely* matched in level. If one speaker is grossly louder than the other, you will hear this mainly as a difference in sound level. But if they differ by only a fraction of a decibel, you are likely to judge the louder one as being clearer, and not attribute the difference to volume at all. Dealers today frequently provide for such level matching in their speaker switchers (the level-match attenuators used should be between the system amplifier and preamp, not between amplifier and speaker). But this match should be rechecked frequently. Of two speakers balanced on, say, pink noise, one might be slightly louder when playing music with a good deal of bass con-



A response curve can be made to look smoother by stretching the horizontal axis.

is full of soft, absorbent surfaces, highs will be weaker. To some extent, the speaker's tweeter and midrange level controls can help compensate for this when you get it home. But, if the dealer's listening room is more absorbent than your own, and you have to turn the tweeter down to make it sound best in the store, then try another speaker—you may not have enough adjustment range left to compensate for the acoustics in your home.

compensating fully for a system with deficient treble response.

Note, too, how speaker placement in a room affects bass response. Resting a speaker on a floor accentuates its bass; placing it on the floor in a corner accentuates it further. Raising it above the floor on a stand (or bookshelf) will reduce bass. Conscientious dealers often try to equalize for these effects by setting up the speakers asymmetrically, so that the speaker nearest the

Pioneer horn tweeter is segmented for dispersion.



Sansui 3-way system.

Note horn tweeter with acoustic lens.

Bose 901 reflects most of its sound from room wall.



Focus On Speaker Systems Continued

tent, and the other slightly louder when playing music strong in treble tones.

As you compare two sets of speakers, spend some time switching quickly between them (preferably in midpassage, not just as the music changes) to hear how each handles essentially the same sounds. Also spend some time listening to each at length.

Listen to as many types of sound as possible. Bring records you're familiar with (fresh copies, if your old ones are worn or dirty), covering as many types of music as possible. Listen also to the noise heard between stations on an FM tuner or receiver.

Why noise, when the emphasis thus far has been on reproducing music naturally? Simply because FM noise contains a balance of all the frequencies over a range of about 50 to 15,000 Hz. Peaks and dips in a speaker's response will often show up quickly on white noise, when you might otherwise have to wait a long time for music to hit a note that would expose them clearly. The sound should be a smooth rushing noise, with both bass and treble clearly present. Grittiness or roughness is one sign of coloration. So is a milky smoothness, usually the sign of insufficient treble. If all you hear is hiss, on the other hand, there's probably too little bass response. The sound should seem high-pitched with no specific pitch attributable to it. Any distinct pitch you can hear is because a resonance overemphasizes a single frequency or narrow frequency band.

Here's an interesting test one can make to check for the nasality or honkiness that afflicts speakers with over-emphasized midrange response. With your hands cupped over your mouth, say "Shhhhh"; then listen to the same sound made with your hands removed. White noise should have the same smooth, rushing quality as in the second example. If the speaker sounds as though its hands were over its mouth, it will add nasal coloration to the music.

Noise is also a good test for high-frequency dispersion. Starting from a point on the speaker's axis, walk to either side until the high-frequency sound quality changes noticeably. Then continue walking slowly until the hissiness disappears from the sound.

The farther from the speaker's axis you must go to reach these points, the broader and more even the speaker's high frequency dispersion. If, with your eyes closed, you can reliably tell just when you're directly on the speaker's axis, its dispersion is deficient.

While you're tuned to FM, listen to some deep-voiced male announcers. They should sound natural, as if they were in the room with you, not as if they were in a rain-barrel or tub. This boominess or chestiness is a sign of a speaker-response peak at about 100 to 200 Hz. (Check several announcers, though, to be certain that the problem doesn't rest with the broadcast studio or your reception area.)

The ultimate speaker test is on music, of course. That, after all, is what you're buying speakers to hear. Each type of music has different information to impart about the speakers you're auditioning.

Try rock music, where it's easy to listen for bass definition. Transient thumps should be sharp and powerful, not softened into a mushy drone. You should be able to play the speaker as loud as you like, using an amplifier of the wattage you intend to use at home without breakup or distortion from speaker or amplifier. (If the amplifier distorts, then you need a more efficient speaker or you must revise your amplifier selection.)

Rock piano should be clear, transparent, almost bell-like. If it's jangly or annoying, that's usually a sign of high-frequency peakiness or distortion; if too soft, and sweet, the speaker system probably lacks satisfactory treble.

Now listen to massed orchestras or—still better—choruses. You should be able to hear them as groups of individual instruments or voices, not a puree of sound. This is one of the best possible tests for speaker clarity.

String instruments are rich in harmonics and, therefore, a good test of distortion and high-frequency response. Solo and chamber recordings should let you hear the bite of bow on string but without rasping. Cellos should sound full, not thin or ponderous. Massed violins should have a silky sheen, not shrill or dull. Animated

passages will reveal more than slow, legato ones.

Organ pedal notes do demonstrate low-bass capability, but they take a long time to build up, so they are not as exacting a test as a good swift thump of bass drum or tympani.

There isn't time in the audio showroom to play every selection on every record you bring as demonstration material. So carefully note what you want to play before you reach the store. If some of your records aren't conveniently divided into bands, you can make a cardboard index that can fit against the spindle as a guide to where to put down the tonearm.

Listen carefully at both the highest levels you're likely to listen to at home and at the lowest. The speaker's sound should not change radically (other than your ears' fading out on bass as it gets lower and a slight loss of treble) as the level diminishes.

Check also for instrument positions. You should be able to differentiate clearly the positions of the various instruments and voices within the stereo fields (easier on some records than others). Be skeptical of speakers with strong, immediate appeal. The speakers that instantly excite you often do so because they sound greatly different from those faithfully reproducing recordings. Perfect speakers, if they existed, would all sound alike. Among high-quality systems a speaker's superiority is likely to be fairly subtle.

Note that every speaker system does not aim all its sound directly forward. Some have drivers facing to the sides, the top, or even to the rear. (And dipoles, of course, project sound equally to both the front and the rear.)

In most cases, this involves midrange and treble drivers whose indirect output, reaching the listener by reflection, may overcome some room acoustic problems, enlarge the apparent sonic space, or simply make the sound richer. Some critics, however, feel that it also diffuses the stereo image or makes solo instruments sound unnaturally large. Here again, the listener should make up his or her own mind. Side-firing woofers, however are there to eliminate an upper-bass dip caused by wall reflections. ◇

SPEAKER SPECIFICATION GUIDE

Manufacturer and model		Price (\$/p-pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (C-cont.; P-peak)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
AAL	Studio 6	430	air susp.	10 4x10 3	— horn piezo	4 1 3	1000 7000	18-25k ±3	94 8	20	200C 400P	2C	38x24x16	90	Fused; pedestal base.	
	Studio 4	300	air susp.	15 4x10 3	— horn piezo	1 1 3	1000 7000	20-25k ±3	93 8	10	150C 300P	2/C	31x24x16	80	Fused; pedestal base.	
	Studio 2001	220	reflex	10 8 3 2	— — piezo	1 1 1 1	600 2000 7000	25-25k ±3	88 8	10	80C 160P	1/C	37x13x11	50		
	Studio 3"	200	air susp.	12 4x10 3	— horn piezo	1 1 1	1000 7000	25-25k ±3	93 8	10	100C 200P	2/C	26x15x13	48	Fused.	
	Studio 2	150	air susp.	10 3 2	— piezo ring	1 1 1	4000 7000	27-25k ±3	92 8	10	50C 100P		25x14x11	32	Fused.	
	Apollo 2915	140	reflex	15 5 2	— cone	1 2	1000 2500	20-22k ±3	91 8	5	50C 100P		30x18x11	44		
	Apollo 8853	130	reflex	8 5 2	— cone	2 1	1000 5000	25-22k ±3	92 8	5	60C 120P		37x13x11	50		
	Apollo 2712	95	reflex	12 5 2	— cone	1 1	1000 5000	25-22k ±3	92 8	5	50C 100P		27x16x11	36		
	Studio 1	90	air susp.	8 2	— —	1 1	4000	35-20k ±3	91 8	5	30C 60P	—	22x11x10	24		
	Acoustat XM	p2600	dipole	2.8 ft ²	elect.	3	—	30-20k ±3	— 50k	—	—	2/C	60x37x2	100	Built-in servo amplifier.	
X	p1995	dipole	—	elect.	—	—	30-20k ±3	— 50k	—	—	2/C	48x28x19	105			
Acoustical Engineering Mach IV	1595	horn	15 8	— —	— horn	1 1	400 2500	16-20k ±5	— 8	10	100	—	41x42x30	175		
	995	horn	12 8	— —	— horn	1 1	500 3000	20-20k ±5	— 8	10	80	—	30x28x22	150		
	Model 5A	895	horn	12 8	— —	1 1	500 3000	20-20k ±5	— 8	10	80	—	30x29x21	125		
Mini-Corner Horn	595	horn	8 4	— —	— horn	1 1	800 5000	32-18k ±5	— 8	10	60	—	24x18x12	85		
Acoustic Research AR9	650	air susp.	12 8 1 1/2	— — dome	— dome	2 1 1	200 1200 7000	28-25k -3	87 4	40	400	3/S	53x15x16	138	Side-firing woofers; extension circuitry.	
	AR10"	450	air susp.	12 1 1/2	— dome	1 1	525 5000	35-25k -3	86 4-8	25	150	3/S	25x14x11	55	Woofer en- vironmental control.	
	AR11	350	air susp.	12 1 1/2	— dome	1 1	525 5000	35-25k -3	86 4	25	150	2/S	25x14x11	50		
	AR12	250	air susp.	10 2 1 1/2	— — dome	1 1 1	700 4000	43-25k -3	86 8	25	150	2/S	25x14x11	38		
	AR14	180	air susp.	10 1	— dome	1 1	1300	43-24k -3	86 8	15	100	1/S	25x14x11	35		
	AR15	130	air susp.	8 1	— dome	1 1	1700	48-24k -3	85 8	15	100	1/S	22x12x8	24		
	AR17	p190	air susp.	8 1 1/2	— press.	1 1	2000	48-21k -3	86 8	15	100	1/S	19x10x9	17	Pairs only.	
	AR18	p130	air susp.	8 1 1/2	— press.	1 1	2000	58-21k -3	86 8	15	100	1/S	17x10x6	14	Pairs only.	
	Acousti-phase Phase III+	300	reflex	12 5 1	— — dome	1 1 1	900 5000	32-20k ±3	— 4-8	10	100C	1	25x15x14	50		
	Tower	260	reflex	10 3 1/2 1	— — dome	1 1 1	1000 5000	40-20k ±3	— 8	8	70C	2	37x13x13	59		
Phase II	220	reflex	10 5 1	— — dome	1 1 1	1200 1500	35-20k ±3	— 4-8	10	70C	1	25x14x13	48			
Monitor	180	reflex	12 1	— dome	1 1	1500	35-20k ±4	— 4-8	10	70C	1	25x14x14	48			
Phase I	130	reflex	8 1	— dome	1 1	1600	40-20k ±4	— 8	5	50C	1	22x13x11	29			
Microphase	90	reflex	6 1/2 1	— dome	1 1	1600	48-20k ±4	— 8	3	30C	—	18x11x8	38			

ABOUT PRICES . . . With repeal of Fair Trade Laws, manufacturers are now providing "Suggested Retail" figures for the guidance of their dealers and customers. Prices stated in the speaker charts are those provided by manufacturers under these conditions. They are, of course, subject to change without notice and some products may be purchased in your trading area at a price that differs from that given here.

Manufacturer and model	Price (\$)(p-pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz : dB)	Sensitivity (SPL in dB at 1 meter, w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (number/type; C=cont, V=variable; S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
Acoustique 3a SB1200	999	—	11	long coil	4	100	25-0.12k ±3	84-96	20k	—	—	1	14x36x30	170	Subwoofer with feedback to built-in 150W amp.
Atom 3	n.a.	labyrinth	6	cone	1	600 6000	120-30k ±3	94	8	15	120C	—	10x9x4	50	Satellite for use with above; "time-aligned." System with 1 SB1200 & 2 Atom 3.
Triphonic	1299	—	—	—	—	—	—	—	—	—	—	—	—	—	120W feedback amp.
Andante Master Control	829	—	10 2 2 1/8x7/8	— dome planar	1 1 1	400	25-40k ±3	94	8/100	5	80C	1	18x12x8	42	—
Arioso Monitor	569	reflex	15 5 1/2	— cone horn	1 1 1	300 5000	45-20k ±3	94	8	50	120C	2	27x18x15	90	—
Andante Linear	555	—	11 2 3/4	— dome dome	1 1 1	400 5000	30-30k ±3	94	8/100	5	80C	1	18x12x8	40	120W feedback amp.
Adagio	435	trans. line	11 2 3/4	— dome dome	1 1 1	500 5000	35-30k ±3	91	8	25	80C	1	31x12x12	67	Built-in 100-Hz filter.
Apogee Monitor	359	labyrinth	11 1 3/8 3/4	— dome dome	1 1 1	700 6000	45-30k ±3	92	8	10	70C	—	29x13x13	45	"Time-aligned."
Allegretto	319	reflex	10 4x8	— horn horn	1 1 1	200 10,000	55-30k ±3	94	8	5	60C	1	25x12x10	35	"Rock speaker."
Apogee	209	reflex	10 3/4	— dome	1 1	4500	55-30k ±3	94	8	5	50C	—	25x12x10	32	"Time-aligned."
Alphase	156	labyrinth	8 3/4	— dome	1 1	5000	55-30k ±3	92	8	5	40C	—	10x10x20	21	"Time-aligned."
ADS															
910	600	air susp.	10 2 1	cone dome dome	2 1 1	500 4000	18-25k ±5	93	4	15	150C 300P	2/S	34x19x15	100	Swivel stand; bi- and tri-ampable.
810	350	air susp.	8 2 1	cone dome dome	2 1 1	550 4000	20-22k ±5	93	4	20	75C 150P	—	26x14x12	47	—
710	265	air susp.	7 2 1	cone dome dome	2 1 1	550 4000	25-22k ±5	93	4	15	65C 130P	—	22x12x11	35	—
2002	225	air susp.	4 1	cone dome	1 1	2500	55-22k ±5	—	50k	—	—	1	7x4x5	5	Built-in biamp; 12V dc or opt. 110V ac.
700	180	air susp.	7 1	cone dome	2 1	1500	30-22k ±5	92	4	15	50C 100P	—	22x12x11	33	—
500	145	air susp.	8 1	cone dome	1 1	1500	30-22k ±5	91	4	15	40C 80P	—	20x12x10	25	—
300	140	air susp.	5 1	cone dome	1 1	2500	68-22k ±5	90	4	10	50C 100P	—	9x6x6	8	Metal cabinet.
400	109	air susp.	7 1	cone dome	1 1	1500	33-22k ±5	91	4	10	50C 100P	—	18x10x9	19	—
200	105	air susp.	4 1	cone dome	1 1	2500	55-22k ±5	90	4	5	30C 60P	—	7x4x5	5	Metal cab.; avail. with bracket for car.
Advent															
Powered Advent Loudspeaker	449	air susp.	12 1 3/8	— cone	1 1	1500	—	—	—	—	—	2	28x14x13	70	Built-in biamp.
New Advent Loudspeaker	159	air susp.	12 1 3/8	— cone	1 1	1500	—	89	8	15	—	1/S	26x14x12	47	—
Advent/1	120	air susp.	12 1 3/8	— cone	1 1	1500	—	89	8	15	—	—	22x13x9	27	—
Advent/2	79	air susp.	10 1 5/8	— cone	1 2	1500	—	80	8	10	—	—	19x11x8	19	—
AEI															
Evolution 1	160	—	10 1	— dome	1 1	1500	35-17k ±2	88	4 or 8	15	75C 150P	1/S	25x16x10	43	Switchable impedance.
Evolution 2	110	—	8 1	— dome	1 1	1500	38-17k ±2	88	4 or 8	15	50C 100P	1/S	21x13x9	30	Switchable impedance.
Akai															
SW-177	275	closed	15 5 1/4 1 1/4	— — —	1 1 2	700 5000	25-20k ±3	94	8	100	40C 100P	2	27x17x12	47	—
SW-157	210	reflex	12 5 1 1/4	— — —	1 1 1	1200 5000	30-20k ±3	92	8	60	30C 60P	2	27x16x12	36	—
SW-137	140	reflex	10 5 1 1/4	— — —	1 1 1	1200 5000	40-20k ±3	92	8	40	20C 40P	1	23x14x12	26	—
SW-127	95	reflex	8 1 1/4	— —	1 1	4000	40-20k ±3	92	8	30	15C 30P	—	20x12x9	16	—
Allison Acoustics															
Allison: One	395	air susp.	10 3 1/2 1	— — —	2 2 2	350 3750	—	86	8	30	40C 400P	2/S	40x19x11	67	Side-firing woofers.
Allison: Two	325	air susp.	8 3 1/2 1	— — —	2 2 2	350 3750	—	86	8	30	40C 400P	2/S	36x16x9	57	"
Allison: Three	275	air susp.	10 3 1/2 1	— — —	1 1 1	350 3750	—	86	4	30	20C 200P	2/S	40x15x10	45	"
Allison: Four	185	air susp.	8 1	— —	1 2	2000	—	86	8	30	20C 200P	2/C, S	11x19x10	24	"
Altac Lansing Model 19	749	vented	15 —	— horn	1 1	1200	30-20k	102	8	10	65C 350P	—	39x30x21	143	Radial phase plug; sectoral horn.

Manufacturer and model		Price (\$ (pr-pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz/Hz · dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (number/type): C-cont. variable; S-switched	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
Model 17	699	vented	15	—	1	1500	30-20k	100 8	10	65C 350P	—	40x26x18	138	Coax; sectoral horn.		
Model 15	479	vented	12	—	1	1700	30-20k	94 8	12	60C 250P	—	27x22x16	84	Radial phase plug.		
Stonehenge II	359	vented	12	—	1	500	35-20k	86 8	20	50C 250P	—	38x16x15	76			
Model 9 Series II	329	vented	5½	cone	1	5000										
			5	cone	1											
			12	—	1	800	40-20k	93 8	12	60C 250P	—	27x18x15	64			
			6½	cone	1	7000										
Santana II	279	vented	5	cone	1	2500	40-20k	91 8	12	45C 150P	—	26x19x16	67			
Model 7 Series II	259	vented	12	—	1	850	45-20k	90 8	15	50C 200P	—	25x16x14	49			
			6½	cone	1	8000										
			4	cone	1											
Model 5 Series II	189	vented	12	—	1	1500	45-20k	92 8	12	45C 150P	—	26x15x12	38			
			4	cone	2											
Model 3 Series II	149	vented	10	—	1	1500	50-20k	91 8	10	35C 100P	—	24x13x12	33			
			4	cone	1											
Model 1 Series II	129	sealed	8	—	1	3500	50-20k	89 8	10	30C 75P	—	23x12x11	60			
			4	cone	1											
Analogue Systems																
AL-5	430	air susp.	10	cone	2	400	19-21k	— 8	7	125P	2/C	35x14x12	70	Two-piece unit.		
		horn	8	cone	1	1500						13x14x13				
		horn	5	cone	1	5500										
		horn	4½	dome	1											
AL-4	300	horn	12	cone	1	1500	20-20k	— 7.5	7	100P	2/C	27x16x13	48			
			5	cone	1	4000										
			4½	dome	1	6500										
			3½	dome	1											
A-550	190	air susp.	10	cone	2	1200	28-20k	— 8	3	70C	C	35x14x12	35			
			4½	cone	1	3500										
			3	cone	1											
AL-3	180	horn	10	cone	1	1500	25-19k	— 7.5	7	90P	2/C	24x14x12	42			
			4½	cone	1	4500										
			3½	dome	1											
A-450	170	air susp.	12	cone	1	1200	35-20k	— 8	3	60C	C	26x16x12	32			
			4½	—	1	3500										
			3	—	1											
A-300	100	air susp.	10	cone	1	1200	35-20k	— 8	3	50C	—	22x12x11	24			
			4½	cone	1	3500										
			3	cone	1											
AL-2	100	reflex	10	cone	1	3500	32-19k	— 8	5	70P	2/C	20x12x11	23			
			3½	dome	1											
Armstrong Audio																
602	275	vented	8	—	1	2300	55-20k ±2	— 8	25	50C 100P	—	24x11x11	25			
			1½	dome	1	7500										
			1	dome	1											
Audioanalyst																
Anthem Array	599	sealed	10	—	2	120	28-25k ±3	86 4-8	15	70C 300P	3/S, C	44x15x15	90	Polymer-treated cone; "time-aligned" staggered mounting.		
		open	4½	—	1	500										
		open	1	dome	1	3000										
		open	—	piezo horn	1	12,000										
M8	359	air susp.	12	long throw	1	600	27-25k ±3	86 8	15	80C 250P	2/S	28x16x12	57	Polymer-treated cone.		
			4½	cone	—	2000										
			1	dome	1	15,000										
			½	—	—											
M6	269	air susp.	10	long throw	1	700	30-20k ±3	86 8	15	55C 150P	2/S	24x14x12	47	"		
			4½	cone	1	2000										
			1	dome	1											
M4	189	air susp.	10	long throw	1	2000	38-20k ±4	88 8	10	40C 100P	—	21x12x11	33	"		
			1	dome	1											
A-100X	169	air susp.	10	long throw	1	2000	33-20k ±4	89 8	10	50C 135P	2/S	23x14x12	37			
			4½	cone	1	8000										
			2	—	—											
M2	149	air susp.	5	long throw	1	2000	55-20k ±4	— 4	7	30C 60P	—	10x6x7	7	Polymer-treated cone.		
			1	dome	1											
Audionics of Oregon																
LO-2	2500	vented	10	—	4	125	20-26k ±1	90 6	70	100C 400P	C	—	200	Spherical satellites; separate woofers; bi-amp crossover.		
			5	—	1	1000										
			1½	dome	1	4000										
			1	dome	1											
T-52	365	vented	10	cone	1	350	32-22k ±2.5	92 4	30	60C 240P	C	48x12x16	90			
			4½	—	1	2500										
			1	dome	1											
Audio Phase																
FW154	390	reflex	15	—	1	800	20-25k ±6	— 8	5	100C 200P	2/C	28x18x16	60	Fused.		
			4x10	horn	1	2500										
			3x7	horn	1	6500										
			3	—	1											
FW124	320	reflex	12	—	1	800	20-25k ±6	— 8	5	100C 200P	2/C	26x16x12	45			
			4x10	horn	1	2500										
			3x7	horn	1	6500										
			3	—	1											
SV123	200	reflex	12	—	1	800	30-19k ±6	— 8	5	50C 100P	2/C	26x16x12	40	Fused.		
			4x10	horn	1	1500										
			3	—	1											
LV123	170	reflex	12	—	1	800	35-19k ±6	— 8	5	40C 80P	—	26x16x12	35	Fused.		
			5	cone	1	1500										
			3	—	1											

Avid	300	350	sealed	12 2 1	— dome dome	1 1 1	500 6000	35-20k ±3	88 8	15	250C	2/S	30x17x10	60	Self-resetting protect circuit.
200	225	sealed	10 4½ 1	— cone dome	1 1 1	475 4000	42-20k ±3	88 8	15	150C	2/S	25x15x10	40	Fused.	
101	175	vented	8 2 1½	cone cone cone	1 2 1	2500	30-18k ±3	85 8	15	70C	—	29x13x13	40		
102	150	—	10 1	cone dome	1 1	2200	44-18k ±3	85 8	15	100C	1/S	25x15x10	36	Fused.	
100	110	air susp.	8 1½	cone cone	1 1	2500	48-18k ±3	85 8	15	75C	1/S	23x14x10	28		
80	85	air susp.	8 1½	cone cone	1 1	3000	66-17k ±3	88 8	8	60C	—	20x12x9	17		
Bang & Olufsen Beovox M-100	490	vented	12 4 2½ 1½ ¾	cone Phase-Link dome dome dome	1 1 1 1 1	50 2500 8000	35-22k ±4	— 4	25	100C	—	30x16x12	61	Frequency-dependent circuit breaker; Phase-Link "linear phase" system; with stands.	
Beovox M-70	395	air susp.	10 5 2½ 1	cone Phase-Link dome dome	1 1 1 1	500 4500	38-20k ±4	— 4	15	70C 125P	—	26x14x11	37	Phase-Link system as above; w/stands.	
Beovox S-75	249	air susp.	10 5 2 1	cone Phase-Link dome dome	1 1 1 1	700 4000	42-20k ±4	— 4	12	75C 100P	—	23x13x10	24	Phase-Link; opt. stands or wall brkt.	
Beovox P-45	175	air susp.	5 3½ 1	cone Phase-Link dome	2 1 1	2000	55-20k ±4	— 4	10	45C 75P	—	26x14x6	18	Wall mounting; Phase-Link.	
Beovox S-45-2	149	air susp.	8 3½ 1	cone Phase-Link dome	1 1 1	2000	49-20k ±4	— 4	10	45C 75P	—	19x10x8	15	Phase-Link; opt. floor stand or wall brkt.	
Beovox P-30	125	air susp.	6½ 1 1	cone dome dome	1 1 1	3000	58-20k ±4	— 4	10	30C 50P	—	22x12x4	11	"Linear phase"; wall-mounting panel.	
Beovox S-35	119	air susp.	8 1 1	cone dome dome	1 1 1	3000	58-20k ±4	— 4	7	35C 50P	—	19x10x8	9	"Linear phase."	
Beovox S-25	95	air susp.	6½ 2	cone dome	1 1	3000	80-16k ±4	— 4	5	25C 40P	—	16x9x6	9	"Linear phase."	
Bedini/Strelloff TS-1	p1995	infinite	10 — —	cone dome dome	2 4 4	500 5000	40-18k ±4	— 8	20	300C	3	57x36x18	—	"Phase-aligned."	
BES	D-120W	599	open	1700 in. ² — —	diaphragm dynamic piezo	— 3 1 4	1200 10,000	35-20k ±3	89 4	30	110C	—	53x20x4	55	Dual planar dia- phragms; upper has separate drivers for midbass, midrange & highs.
D-75W	449	open	850 in. ² — —	diaphragm dynamic piezo	— 2 1 1	1000 9000	38-20k ±3	91 4	25	60C	—	32x22x4	35		
D-60W	299	open	850 in. ² — —	diaphragm dynamic piezo	— 2 1 1	800 10,000	40-20k ±3	88 8	25	150C	—	28x20x4	25	Planar diaphragm with 3 drivers for diff. freq. ranges.	
U60	199	open	— — —	— — —	— 2 1 2	800	42-18k ±3	88 8	20	—	—	26x18x4	20	As above, with 2 drive coils.	
U50	139	open	— — —	— — —	— — —	3000	50-20k ±3	88.5 4	15	—	—	22x14x4	15		
Beta Sound 1001B	650	horn/vented	15 — —	— horn horn	1 1 1	400 4500	30-18.5k ±3	100 8	30	100C 200P	1/S	41x22x26	130		
075	500	horn/vented	12 — —	— horn horn	1 1 1	600 4500	30-18.5k ±3	97 8	15	75C 150P	1/S	38x21x17	100		
050	430	vented	12 — —	— horn horn	1 1 1	600 4500	30-18.5k ±4	97 8	15	75C 150P	1/S	40x17x18	80		
045	370	vented	12 — —	— horn horn	1 1 1	6000 4500	35-18.5k ±4	97 8	15	75C 150P	1/S	25x17x15	70		
Harold Beveridge System 3	10,000	line source	— — —	elect. — —	1 — —	—	25-20k ±2	— —	—	—	C	—	200	Vertical line source acoustic lens; built-in 1500-WA	
System 2SW	6000	line source	12 — —	— elect. elect.	2 1 1	70	30-18k ±2	— —	—	—	C	78x24x15	150	As above, w/subwoofer.	
System 2 Beveridge Jr.	1800 1500	line source line source	— 10 —	— — elect.	— 2 1	— 125	50-18k ±2 35-18k ±2	— — 80 4	— 50	— 100C 300P	— C	78x24x15 72x16x16	100 75	As above, w/o subwoofer.	
B.I.C.															
BML Electronics 2001 Sound Odyssey	549	planar column	8 8 1½	— — —	ABR 1 2	1500 5000	35-20k ±3	94 6	25	80C 200P	—	64x24x6	90	Data not available for new models.	
1001 Sound Window	349	planar column	8 8 1½	— — —	ABR 1 1	1500 5000	48-20k ±3	92 5.2	20	70C 150P	—	32x22x5	40		

Manufacturer and model

Bolivar Speaker Works
64

18

125

Bose

901

601

501

301

Bozak

Concert Grand

CS 4000 Symphony

CS-501 Concerto

LS 400

LS 300

LS 250

LS 200

Braun

L-1030

L-300

L-200

LVP-100

Output C

Burhoe Acoustics

Silver

Blue

Light Blue

White

Green

B&W

OM6

DM7

OM4

DM5

Calibration Standard

Instruments

MDM-4

Cambridge/Cybervox

TL 200

TL 100

Cannon TLS

1230-T

Price (\$)	Price (\$ per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz - dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (number/type): C=cont.; P=peak; V=variable; S=switched	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
190	vented	10	—	1	800	—	89 4	10	50C 100P	C	27x14x12	44			
		5	—	1	3000	—									
		2	—	1		—									
145	vented	8	—	1	1000	—	86 4	10	45C 90P	C	23x13x11	34			
		5	—	1	3000	—									
		2	—	1		—									
115	vented	8	—	1	2000	—	86 4	10	35C 70P	—	23x13x11	31			
		2	—	1		—									
765	vented special	4 1/2	cone	9	—	—	— 8	10	—	2	21x13x12	35			1 direct, 8 reflecting drivers; w/ active equalizer.
279	vented	8	—	2	2000	—	— 8	15	150C	—	25x15x13	36			Top and front radiating.
		3	—	4		—									
199	air susp.	10	—	1	1500	—	— 4	20	150C	—	24x15x14	42			Tweeters reflect off walls.
		3 1/2	—	—	3000	—									
109	vented	8	—	1	1200	—	— 8	10	60C	—	11x15x10	18			Aimable tweeters reflect off side wall.
		3	—	1	3000	—									
1365	infinite	12	—	4	400	28-20k	— 8	—	—	—	52x36x19	225			
		6	cone	2	2500	—									
		2 1/2	cone	8		—									
870	infinite	12	—	2	400	35-20k	— 8	—	—	—	44x27x16 or 30x39x16	190			Avail. in vert. or horiz. cab.
		6	cone	1	2500	—					32x20x16				
		2 1/2	cone	8		—									
450	infinite	12	—	1	400	40-20k	— 8	—	—	S		90			
		6	cone	1	2500	—									
		2 1/2	cone	3		—									
300	infinite	12	—	1	800	40-20k	—	20	—	S	25x18x14	65			
		6	cone	1	2500	—									
		2 1/2	cone	2		—									
250	vented	12	—	—	—	—	—	20	—	—	—	—			
190	infinite	12	—	1	800	45-20k	—	20	—	S	23x15x12	48			
		4	—	1	2500	—									
		2 1/2	—	1		—									
115	vented	8	—	1	2000	45-20k	—	20	—	—	20x12x11	34			
		2 1/2	—	1		—									
840	infinite	10	—	1	500	—	— 4.8	25	100C 140P	—	28x12x10	40			
		2	dome	1	3000	—									
		3/4	dome	1		—									
400	infinite	5	—	1	600	—	— 4	12	40C 50P	—	10x6x7	14			
		1	dome	1	3000	—									
		3/4	dome	1		—									
270	infinite	5	—	1	1500	—	— 4	12	40C 50P	—	10x6x6	11			
		1	dome	1		—									
260	infinite	2 1/2	—	1	1500	—	— 4	12	35C 50P	—	7x4x4	7			Swivel mtg. brkt.
		1	dome	1		—									
230	infinite	2 1/2	—	1	1500	—	— 4	12	35C 50P	—	7x4x4	6			
		1	dome	1		—									
450	vented	10	—	1	1000	24-26k ±2	97 6	50	100C 200P	1/C	—	58			Angled, side-firing tweeters.
		1 1/2	inv. dome	1	2000	—									
		1 1/8	inv. dome	3	3000	—									
225	vented	10	—	1	1000	30-16k ±2	96 5	25	75C 175P	2/C	14x24x11	36			
		1 1/2	inv. dome	1	2000	—									
		1 1/8	inv. dome	1		—									
150	vented	10	—	1	1500	30-16k ±2	98 5	15	60C 175P	1/C	14x24x10	35			
		1 1/2	inv. dome	1		—									
140	vented	8	—	1	1800	35-26k ±2	94 5	20	50C 150P	1/C	22x14x10	29			
		1	inv. dome	1		—									
110	vented	8	—	1	2000	40-16k ±2	97 5	8	35C 100P	1/S	18x11x10	22			
		1 1/2	inv. dome	1		—									
655	sealed	8 7/8	cone	1	500	50-20k ±3	86 8	25	350C	2	37x16x15	—			"Linear-phase" staggered cab.; sys-tem & tweeter fused.
		5 1/8	cone	1	5000	—									
		3/4	dome	1		—									
545	pass. rad.	—	cone	1	—	70-20k ±2	— 8	50	200C	1	36x11x15	—			"Linear-phase" staggered; fused.
		—	dome	1		—									
259	vented	6 1/2	cone	1	2500	80-20k ±5	88 8	10	30C	—	21x10x10	—			Fused.
		1 3/8	cone	1	14,00	—									
		3/4	dome	1		—									
159	sealed	5 1/2	cone	1	4500	100-20k ±5	87 8	10	25C	—	18x9x10	—			Fused.
		3/4	dome	1		—									
230	vented	6 3/4	—	2	1500	70-17k ±3	89 8	10	40C 100P	none	13x19x10	23			For "near-field" monitoring; fused.
		3 1/2	—	1		—									
599	trans. line	13x8	—	1	400	—	— 8	20	50C 90P	—	42x18x13	98			
		—	—	1	3000	—									
		—	—	1	10,000	—									
		—	—	1		—									
499	trans. line	13x8	—	1	400	—	— 8	20	40C 70P	—	31x13x13	52			
		—	—	1	3000	—									
		—	—	1		—									
399	pass. rad.	12	—	1	400	—	— 8	18	185P	3/S, C	14x14x39	61			
		5 1/2	—	1	3500	—									
		2x5	horn	1		—									
		—	piezo	1		—									

Manufacturer and model		Price (\$)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz)	Sensitivity (SPL in dB at 1 meter w/1W)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (number/type, C=cont., S=switch)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
1230	299	pass. rad.	12 5 1/2 2x5	— horn piezo	1 1 1 1	400 3500	—	— 8	15	170P	3	14x14x25	41			
1030	249	pass. rad.	10 5 1/2 2x5	— horn piezo	1 1 1 1	400 3500	—	— 8	12	150P	3/S, C	14x14x25	39			
1020	179	pass. rad.	10 2x5	— horn piezo	1 1 1 1	3500	—	— 8	10	90P	2/S, C	12x14x22	31			
Canton LE-900	758	infinite	11 2 1 1 1/8 3/4 7 1 1/2	— dome dome dome dome dome dome dome	1 1 1 1 1 1 1 1	700 2100	—	— 4-8	40	90C 130P	—	23x13x11	32	Floor stand opt.		
Gamma 800L	558	infinite	8 1 1/8 3/4 7 1 1/2	— dome dome dome dome dome dome dome	1 1 1 1 1 1 1 1	750 2200	—	— 4-8	25	80C 120P	—	11x11x11	22			
LE-600	558	infinite	7 1 1/2 1 1 1/2 1 1/2	— dome dome dome dome dome dome dome	1 1 1 1 1 1 1 1	680 2700	—	— 4-8	30	70C 100P	—	20x11x10	24			
LE-400	370	infinite	6 1 1/2 1 1 1/2 1 1/2	— dome dome dome dome dome dome dome	1 1 1 1 1 1 1 1	750 2600	—	— 4-8	20	20C 55P	—	15x9x8	14			
LX-300	240	infinite	4 1/2 1 1 1/2 1 1/2	— dome dome dome dome dome dome dome	1 1 1 1 1 1 1 1	1600	—	— 4-8	10	30C 45P	—	10x6x5	6			
HC-100	180	infinite	4 1 1 1/2 1 1/2	— dome dome dome dome dome dome dome	1 1 1 1 1 1 1 1	1700	—	— 4-8	10	15C 25P	—	5x8x6	4			
Celestion Industries Ditton 66	530	pass. rad.	12 12 2 1 1 1/2 1 1/2	— pass. rad. dome dome dome dome dome dome dome	1 1 1 1 1 1 1 1	500 5000	40-25k ±4	83	8	10	160P	—	40x15x12	66		
Ditton 25	350	pass. rad.	12 12 1 1/2 1 1 1/2 1 1/2	— pass. rad. dome dome dome dome dome dome dome	1 1 1 1 1 1 1 1	2000 9000	45-25k ±4	85	8	10	120P	—	32x14x11	42		
Ditton 44	310	air susp.	12 6 1 1 1/2 1 1/2 1 1/2	— cone dome dome dome dome dome dome dome	1 1 1 1 1 1 1 1	500 5000	50-25k ±4	84	8	10	100P	—	30x15x10	45		
Ditton 33	260	air susp.	12 5 1 1 1/2 1 1/2 1 1/2	— cone dome dome dome dome dome dome dome	1 1 1 1 1 1 1 1	500 5000	50-20k ±4	83.5	8	10	80P	—	24x14x11	34		
UL6	180	pass. rad.	6 6 1 1 1/2 1 1/2 1 1/2	— pass. rad. dome dome dome dome dome dome dome	1 1 1 1 1 1 1 1	2500	70-20k ±4	79	8	20	80P	—	12x16x9	17		
Ditton 15	160	pass. rad.	8 8 1 1 1/2 1 1/2 1 1/2	— pass. rad. dome dome dome dome dome dome dome	1 1 1 1 1 1 1 1	2500	60-20k ±4	84	8	10	60P	—	21x10x9	17		
Cerwin-Vega 417R	400	reflex	15 6 — — — — — —	— horn — — — — — — —	1 1 1 1 1 1 1 1	300 3500	30-19k ±4	103	4-8	0.5	200C	2/C	29x18x18	82	Min. power input is for 100 dB SPL; hi-freq. circuit breaker.	
S1	350	reflex	12 6 — — — — — —	— Dhorm — — — — — — —	1 1 1 1 1 1 1 1	300 4000	28-20k ±4	98	4-8	2	200C	1/C	25x15x14	55	As above, but with Thermo-Vapor suspension, base equalizer.	
12TR	350	reflex	12 6 — — — — — —	— super Dhorm horn — — — — — — —	1 1 1 1 1 1 1 1	250 4000	35-20k ±3	100	4-8	1	100C	3/C	40x14x14	88	As for 417R, but fuse-protected.	
312	300	reflex	12 6 — — — — — —	— horn — — — — — — —	1 1 1 1 1 1 1 1	300 3500	30-17k ±4	100	4-8	1	150C	2/C	26x16x16	63	As for 417R above.	
R-123	280	reflex	12 6 — — — — — —	— Dhorm — — — — — — —	1 1 1 1 1 1 1 1	500 5000	38-20k ±4	97	4-8	2	50C	2/C	25x15x12	50	"	
212	250	reflex	12 — — — — — — —	— horn — — — — — — —	1 1 1 1 1 1 1 1	2000	35-17k ±4	100	4-8	1	100C	1/C	26x16x16	58	"	
36R	220	reflex	12 5 2 1/2 — — — — —	— dhorm — — — — — — —	1 1 1 1 1 1 1 1	500 2500	38-20k ±4	96	4-8	2	75C	2/C	25x15x12	40	"	
R12	200	reflex	12 — — — — — — —	— Dhorm — — — — — — —	1 1 1 1 1 1 1 1	2000	38-20k ±4	97	4-8	2	50C	1/C	25x15x12	43	"	
25	180	reflex	12 2 1/2 — — — — —	— — — — — — —	1 1 1 1 1 1 1 1	2500	38-20k ±4	94	4-8	4	40C	1/C	25x15x12	39	"	
R-10	160	reflex	10 1 — — — — — —	— dome — — — — — — —	1 1 1 1 1 1 1 1	1200	38-20k ±4	92	4-8	6	40C	1/C	24x13x12	39	"	
311R	150	reflex	12 5 1 — — — — —	— horn — — — — — — —	1 1 1 1 1 1 1 1	1500 3000	32-20k ±4	100	4-8	4	40C	1/C	20x16x15	57	"	
Chartwell PM 450 Electronic	3000	reflex	12 1 — — — — —	— cone dome — — — — — — —	1 1 1 1 1 1 1 1	1800	45-20k ±2	— 20k 600	—	—	1, amp	30x18x16	70	Adj. sensitivity; switchable impedance; w/amp.		
PM 450 Passive	2100	reflex	12 1 — — — — —	— cone dome — — — — — — —	1 1 1 1 1 1 1 1	1800	45-20k ±3	92	8	—	350P	—	30x18x16	70		
PM 400	1650	reflex	12 5 1 — — — — —	— cone cone dome — — — — — — —	1 1 1 1 1 1 1 1	500 3500	45-22k ±3	87	8	—	100C 250P	—	34x15x13	30		
PM 200	400	reflex	8 1 — — — — —	— cone dome — — — — — — —	1 1 1 1 1 1 1 1	3500	45-22k ±3	86	8	—	50C 125P	—	26x11x14	33		

69

Manufacturer and model

Price (\$)

Enclosure type

Driver size (in.)

Driver type

Number

Crossover frequency (Hz)

Frequency response (Hz-Hz -dB)

Sensitivity (SPL in dB at 1 meter w/1W input)

Impedance (ohms)

Min. input (watts)

Max. input (watts)

Level controls (number/type)

C-cont. variable (S-switched)

Dimensions (H x W x D) (in.)

Weight (pounds)

Remarks

AMT Monitor	608	pass. rad.	12	—	1	1000	35-23k ±3	90	6	—	375P	C	39x16x16	104	
			12	pass. rad.	1										
			21.5 in. ²	Heil AMT	1										
AMT 1B	488	pass. rad.	12	—	1	1000	30-23k ±3	90	6	—	375P	C	35x16x16	85	
			12	pass. rad.	1										
			21.5 in. ²	Heil AMT	1										
AMT 1B Bookshelf	416	pass. rad.	12	—	1	1000	40-23k ±3	90	6	—	375P	C	24x14x14	65	
			12	pass. rad.	1										
			21.5 in. ²	Heil AMT	1										
Tempest LS-4	348	pass. rad.	10	—	1	2400	35-24k ±3	96	6	—	160P	C	35x13x12	48	
			10	pass. rad.	1										
			10	Heil AMT	1										
AMT 10B	334	pass. rad.	10	—	1	1400	40-22k ±3	90	6	—	275P	C	24x14x14	55	
			12	pass. rad.	1										
			20.25 in. ²	Heil AMT	1										
Performance PS-4	322	pass. rad.	10	—	1	2400	35-24k ±3	96	6	—	160P	—	35x13x12	48	
			10	pass. rad.	1										
			10.4 in. ²	Heil AMT	1										
Tempest LS-5	241	pass. rad.	10	—	1	2400	40-20k ±3	95	6	—	140P	—	24x14x14	36	
			10	pass. rad.	1										
			10	Heil AMT	1										
Performance PS-5	234	pass. rad.	10	—	1	2400	40-20k ±3	95	6	—	140P	—	24x14x14	36	
			10	pass. rad.	1										
			10.4 in. ²	Heil AMT	1										
Tempest LS-8	179	pass. rad.	8	—	1	2400	50-20k ±3	94	6	—	100P	C	22x13x11	30	
			10	pass. rad.	1										
			10	Heil AMT	1										
Performance PS-8	172	pass. rad.	8	—	1	2400	50-20k ±3	94	6	—	100P	—	22x12x11	30	
			10	pass. rad.	1										
			10.4 in. ²	Heil AMT	1										
Fisher															
ST 461	350	reflex	15	—	1	1000	40-20k ±10	92	8	25	130C	2/S	29x18x15	53	Circ. breaker.
			5	cone	2	500									
			3	horn	1										
ST 661A	330	pass. rad.	12	—	1	700	39-22k ±5	94	8	40	125C	2/S	29x18x13	45	Circ. breaker.
			2	dome	1	7000									
			1	dome	1										
ST 451	290	reflex	12	—	1	1000	45-20k ±10	91	8	20	100C	S	27x17x14	44	Circ. breaker.
			5	cone	2	5000									
			3	dome	1										
ST 641A	280	pass. rad.	10	—	1	700	40-20k ±5	92	8	30	90C	2/S	27x17x12	37	Circ. breaker.
			2	dome	1	7000									
			3	dome	2										
XP 95B	250	air susp.	15	—	1	—	—	—	8	75	—	—	28x18x13	44	
			5	—	2										
			3	dome	1										
ST 441	240	reflex	12	—	1	1000	45-18k ±10	90	8	12	75C	1/S	26x16x13	36	Circ. breaker.
			5	cone	1	5000									
			3	dome	1										
ST 430	180	air susp.	10	—	1	1000	50-17k ±10	90	8	6.5	50C	—	26x16x13	34	
			5	cone	1	5000									
			3	cone	1										
XP 335	180	vented	12	—	1	1500	—	—	8	20	70C	—	24x15x11	30	
			5	—	1	5000									
			3	—	1										
XP 330	160	air susp.	12	—	1	1500	—	—	8	17	50C	—	23x15x11	27	
			5	—	1	5000									
			3	—	1										
XP 325	130	air susp.	10	—	1	1500	—	—	8	12	35C	—	22x14x9	19	
			5	—	1	5000									
			3	—	1										
ST 420	120	pass. rad.	8	—	1	5000	50-16k ±10	90	8	3.5	35C	—	22x14x10	19	
			3	cone	1										
MS 135A	100	pass. rad.	8	—	1	6000	70-16k ±10	91	8	5	35C	—	24x15x11	19	
			3	cone	1	8000									
			2	cone	1										
MS 125A	90	pass. rad.	8	—	1	6000	70-14k ±10	91	8	4	30C	—	22x14x9	15	
			2	cone	1										
MS 115A	80	pass. rad.	6½	dual cone	1	8000	80-12k ±10	90	8	3	22C	—	22x14x9	14	
XP 320	80	vented	8	—	1	5000	—	—	8	8.5	25C	—	19x11x9	12	
			3	—	1										
Frankmann Research															
Frankmann	1295	infinite	12	—	8	200	20-22k ±4	98	8	10	200P	2/S	bass: 31x52x24	240	3-pc. syst.; satellites
			8	—	8	4000							satellites: 38x10x6		fit stands (incl.) or
			—	horn	2	10,000							satellites: 29x30x20		wall.
			—	cone	2								satellites: 22x10x6		
Mini-Frank	895	air susp.	12	—	4	200	30-22k ±4	92	6	10	125P	2/S	bass: 31x52x24	105	
			8	—	4	4000							satellites: 29x30x20		
			—	horn	2	10,000							satellites: 22x10x6		
			—	cone	2										
Frazier															
Frazier Eleven	1300	vented	15	—	1	400	15-25k ±5	103	4	1	100C	2/S	55x30x18	250	
			12	—	1	4000					150P				
			4	cone	4										
			—	piezo	2										
Frazier's Thing	1000	vented	12	—	1	800	20-25k ±5	99	4	1	60C	2/C	48x24x18	146	
			10	—	1	4000					90P				
			3x14	horn	1										
			—	piezo	2										

Manufacturer and model	Price (\$ (p=per pair))	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz - dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (number/type): C=cont. variable, S=switched	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
Seven	470	vented	12 4	— cone piezo	1 2 2	400 4000	25-25k ±5	99 8	1	50C 75P	2/C	29x19x16	98		
Mark V	350	vented	12 4	— cone piezo	1 2 1	500 4000	30-25k ±5	96 8	1	50C 75P	2/C	26x14x12	55		
Concerto	290	vented	10 3x7	— horn piezo	1 1 1	2000 4000	35-25k ±5	93 8	1	30C 45P	1/C	22x16x16	56	End table ht.	
Mark IV-A	210	vented	10 3x7	— horn	1 1	2000	40-16k ±5	93 8	1	30C 45P	1/C	24x14x12	44		
Monte Carlo	150	vented	8 3	— — piezo	1 1 1	3800	50-25k ±5	95 8	1	30C 45P	—	19x11x12	31		
CAD-1	100	vented	8 3 1/4	— —	1 1	3000	50-15k ±5	96 8	1	15C 30P	—	19x11x11	21		
Fried Products H/II	1900 (syst.)	trans. line	10 5 1	cone cone dome	2 1 1	75 3500	20-20k ±3	87 8	25	70C 500P	—	24x45x24	200	Subwoofer + satellite; kit, \$800.	
T Subwoofer	1400	trans. line	10	dome cone	2	75	20-20k ±3	91 8	25	70C 500P	—	24x45x24	170	2-ch. subwoofer of above; also avail- able as kit.	
M/II	850	trans. line	8 5 1	cone cone dome	1 1 1	125 3500	20-20k ±3	90 8	25	70C 500P	—	43x22x12	90		
R/III	400	line tunnel	10 5 1	cone cone dome	1 1 1	350 3000	30-20k ±3	89 8	25	50C 250P	S	28x16x14	60		
W	260	line tunnel	8 3 1	cone — dome	1 1 1	800 3000	40-20k ±2	89 8	25	35C 250P	S	25x14x10	45		
B/2	250	infinite	5 1	— dome	1 1	3200	60-20k ±3	87 8	25	35C 500P	—	12x8x6	14		
A	195	line tunnel	8 1	— dome	1 1	2500	45-20k ±2	88 8	25	35C 250P	S	20x12x10	30		
Q	140	line tunnel	8 1	— dome	1 1	2500	45-18k ±2	88 8	25	35C 200P	S	20x12x10	30		
Gale Electronics GS 401A	500	air susp.	7 7/8 4 3/4	— — dome	2 1 1	475 5000	35-20k ±5	— 4-8	50	100C 200P	C	13x24x11	48	"Sealed midrange."	
GC Electronics Audio Trek IV	101	air susp.	12 4 1/4 1 1/4	cone cone ring	1 1 1	—	35-22k	— 8	10	45C	—	24x15x10	35		
Audio Trek III	72	air susp.	10 3	cone cone	1 1	—	35-22k	— 8	5	35C	—	20x12x10	20		
Genesis Physics Genesis 3	299	pass. rad.	10 8 4 1	pass. rad. — — inv. dome	1 1 1 1	45 800 3000	32-20k ±4	87 8	20	40C 100P	2/S	38x15x12	52		
Genesis II+	219	pass. rad.	10 8 1	pass. rad. — inv. dome	1 1 1	45 1800	32-20k ±4	88.5 8	15	40C 80P	1/S	33x15x11	44		
Genesis II	155	pass. rad.	10 8 1	pass. rad. — inv. dome	1 1 1	45 1800	32-20k ±4	88 8	12	40C 80P	1/S	27x15x12	37		
Genesis I	99	air susp.	8 1	— inv. dome	1 1	1800	45-20k ±4	88 8	12	40C 60P	—	21x12x9	24		
Genesis 6	75	air susp.	6 1/2 1	— inv. dome	1 1	1800	60-20k ±5	88 8	12	40C 60P	—	18x10x7	17		
GLI Model 4	1700	horn	15 15 — —	— pass. rad. horn horn	2 2 2 1	750 7000	30-20k ±4	103 8	50	260C 1100P	—	80x36x30	195		
Model 3	898	horn	15 20x15 3	— horn —	2 1 7	850 7000	30-20k ±5	101 8	50	200C 900P	—	50x36x30	150		
Model 2	696	reflex	15 5 3	— cone horn	2 8 4	350 7000	35-20k ±5	98 8	50	200C 600P	—	36x22x21	130		
Model 1	548	reflex	15 14x3 3	— horn horn	2 1 3	975 7000	35-20k ±5	98 8	25	175C 500P	—	36x22x21	90		
Mono	448	pass. rad.	15 15 — —	— pass. rad. horn piezo	1 1 2 4	875 7000	35-20k ±5	96 8	25	100C 300P	—	36x22x14	75		
FRA-1	388	pass. rad.	15 5 1/4 —	pass. rad. — piezo	1 8 4	7000	48-20k ±3.5	93 4	50	100C 300P	—	24x24x10	36		
Grafyx Audio Products Grafyx SP-Ten	149	vented	10 1	— dome	1 1	2000	35-18k ±3	88 8	10	75C	—	27x15x14	48		
Grafyx SP-Eight	125	vented	8 1	— dome	1 1	2000	39-18k ±3	87 8	10	75C	—	25x14x10	39		

Manufacturer and model		Price (\$ (p=per pair))	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (number/type; C=cont, V=variable, S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
Grafyx SP-Seven		99	air susp.	8 1	— dome	1 1	2000	43-19k \pm 3	86	8	10	50C	—	23x13x9	32	
Hartley Products Reference		1525	infinite	24 10 7 1	— cone cone dome	1 1 1 1	250 3000 7000	16-25k	93.5	5-8	25	300C 400P	—	50x36x24	300	
Concertmaster		1225	infinte	18 10 7 1	— cone cone dome	1 1 1 1	250 3000 7000	16-25k	93	5-8	25	300C 400P	—	42x29x18	150	
Holton Tower		450	infinite	10 1	— dome	2 1	3000	20-25k	92	4	15	150C 200P	—	50x20x14	105	
Zodiac 300A		250	infinite	10 1	— dome	2 1	2000	30-25k	94	4	5	100C 150P	—	25x14x12	65	
Zodiac '77		175	infinite	10 1	— dome	1 1	2000	35-25k	92.5	8	5	100C 150P	—	30x15x12	50	
Zodiac 1A		135	infinite	10 1	— dome	1 1	2000	40-25k	92.5	8	5	100C 150P	—	22x15x9	35	
Zodiac Jr.		90	infinite	8 2	— cone	1 1	2500	50-18k	90.5	8	5	50C 75P	—	19x12x8	25	
Heath AS-1348		290 p540	air susp.	15 4 1/2 1	— — dome	1 2 3	500 3000	28-20k \pm 3	—	8	8	250C	S	38x24x15	110	Kit; ea. driver fused; rear-mounted woofer.
AS-1373		160 p300		10 4 1/2 1	— — dome	1 1 1	500 3000	40-20k \pm 3	—	8	11	200C	2	26x15x12	68	
AS-1344		130		6 1/2 1	— dome	2 2	4000	55-20k \pm 3	—	4	6	100C	1/S	40x11x11	—	As above; radiates from 2 adj. sides.
AS-1352		100 p180		10 1 1/4	— —	1 1	2800	45-18k \pm 3	—	8	6	100C	1/S	24x14x11	55	Kit.
AS-1363		p190		10 4 1/2 1	— — dome	1 1 1	750 4000	45-18k \pm 3	—	8	5	130C	2/S	25x14x11	—	Kit.
HED H-15		250	reflex	15	—	1	2000	32-16k \pm 4	103	4-8	0.5	100C	1/C	29x18x18	63	
W-12		160	reflex	12	horn	2	2000	38-20k \pm 4	97	4-8	2	50C	1/C	25x15x12	42	
W-10		150	reflex	10	Dhorn	1	2000	38-20k \pm 4	92	4-8	6	40C	1/C	25x15x12	39	
H-12		130	reflex	12	Dhorn	1	2000	38-20k \pm 4	97	4-8	2	50C	1/C	25x15x12	33	
H-10		120	reflex	10	Dhorn	1	2000	38-20k \pm 4	92	4-8	6	40C	1/C	25x15x12	31	
Hitachi HS-530		350	air susp.	10 2 1/8 1	cone cone dome	1 1 1	900 3000	30-17k \pm 5	—	6	—	—	—	25x14x11	38	Metal cones.
HS-330		250	air susp.	10 2 1/4 1 1/2	cone cone cone	1 1 1	900 4000	40-18k \pm 4	—	6	—	—	—	23x12x12	32	
HS-371		200	air susp.	12 6 1	— cone dome	1 1 1	1500 6000	—	—	8	—	—	—	24x15x13	35	
HS-323R		140	air susp.	10 1	— dome	1 1	3000	—	90	8	—	—	—	22x12x12	24	
IMF Electronics RSPM Mark IV		1250	trans. line	11 3/4x8 1/4 6 1 1/4	flat cone —	1 1 1	350 3000 13,000	17-ultrasonic	—	—	50	150C	3	40x20x17	119	
Monitor TSL 80 II		925	trans. line	11 3/4x8 1/4 6 1 1/4	flat cone —	1 1 1	350 3000 13,000	20-ultrasonic	—	—	40	100C	1	39x18x16	97	
Studio TSL 50 II		550	trans. line	8 4 —	cone cone dome	1 1 1	375 3000 15,000	23-ultrasonic	—	4-8	30	70C	1	36x15x14	60	
Studio ALS 40 II		425	active line	8 8 4	cone cone cone	1 1 1	150 375 3000	28-20k	—	4-8	25	60C	1	27x14x14	40	Trans. line terminated by 2nd woofer w. different resonant freq.
Super Compact		245	reflex	8 4 —	dome cone cone	1 1 1	375 3000	30-20k	—	4-8	20	50C	—	18x12x11	20	
Compact II		160	reflex	6 1/2 —	dome cone	1 1	4000	35-20k	—	4-8	15	40C	—	15x10x9	13	
Infinity Quantum Reference Standard		p6500	dipole	15 — 18	cone EMIT line source	1 20 3	variable	18-32k \pm 2	—	4	150 bass 100 h-f	350 bass 350 h-f	3/C, 3/S	80x48x24	300	"Watkins dual-drive woofers"; el. crossover.
Quantum Line Source		1200	air susp.	12 — —	cone dome line source	1 6 8	200 500 4000	18-32k \pm 2	—	4	100	500C	3/C	66x18x15	190	"Watkins woofer."

75

Manufacturer and model		Price (\$ (p-pair))	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz -dB)	Sensitivity (SPL in dB at 1 meter w/ 1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level control (number/type): C=cont. variable; S=switched	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
319		230	vented	12 5 1/2 2 1/2	cone cone cone	1 1 1	1200 3000	—	— 8	10	100C	—	25x15x12	40	One rear-fire tweeter.	
CL-4		225	vented	10 4 1/2 1	cone cone dome	1 1 1	500 5000	30-22k ±3	— 8	25	200C	2/S	27x14x13	59		
Pistol CT 38		209	—	8 1/2 2 1/2 —	cone cone —	2 2 2	—	—	— 4	10	75C	—	41x11x11	—		
Classic One		199	air susp.	10 1 —	cone dome —	1 1 1	1900	—	— 8	15	60C	C	24x12x12	—		
318		190	vented	12 2 1/2 10	cone cone cone	1 1 1	—	56-18k	95 8	10	75C	1/C	23x14x11	—		
CL-3		170	vented	10 2 1/2 2	cone cone cone	1 1 1	1500 10,000	35-20k ±3.5	— 8	20	100C	—	26x14x12	53		
CB-10		135	vented	10 2 1/2 10	cone cone cone	1 1 1	—	40-18k ±4	— 8	10	100C	1/S	20x15x7	35		
317A		130	vented	10 2 1/2 8	cone cone cone	1 1 1	—	45-18k	— 8	10	50C	1/C	23x12x10	—		
CB-8		115	vented	8 2 1/2 8 1/2	cone cone cone	1 1 1	—	47-18k ±4	— 8	8	100C	1/C	20x11x7	27		
331A		99	vented	8 1/2 2 1/2 2 1/2	cone cone cone	1 1 1	—	50-18k	— 8	8	50C	—	21x12x9	—		
Klipsch Klipschorn		1651	horn	15 — —	— horn horn	1 1 1	400 6000	35-17k ±5	104 8 at 4 ft	—	105C	—	52x31x29	200		
Belle Klipsch		1374	horn	15 — —	— horn horn	1 1 1	400 6000	45-17k ±5	104 8 at 4 ft	—	105C	—	36x30x19	125		
Cornwall		746	vented	15 — —	— horn horn	1 1 1	600 6000	38-17 ±5	98.5 8 at 4 ft	—	105C	—	36x26x16	108		
La Scala		618-671	horn	15 — —	— horn horn	1 1 1	400 6000	45-17k ±5	104 8 at 4 ft	—	105C	—	35x24x25	110		
Heresy		436	inf. baffle	12 — —	— horn horn	1 1 1	700 6000	50-17k ±5	96 8 at 4 ft	—	105C	—	21x16x13	55		
Koss Model One A		1500	dipole	1845 in. ² 461 in. ² 108 in. ² 14 in. ²	elect. elect. elect. elect.	1 1 1 1	250 1600 6500	32-20k -3	83 4	75	300P	—	49x32x10	150		
Model Two		750	dipole	615 in. ² 165 in. ² 1	elect. elect. dynamic	1 1 1	250 2500	37-19k ±3	— 4	75	300P	1/C	41x24x12	82		
CM/1030A		425	reflex	10 5 1 1	cone cone dome dome	1 2 1 1	400 2500 6000	29-19k -3	96 4	15	200P	3/S	39x17x15	74		
CM/1020A		325	reflex	10 5 1	cone cone dome	1 1 1	450 3000	31-18.5k -3	95 4	15	150P	2/S	33x16x14	60		
CM/1010A		225	reflex	10 8 1	pass. rad. cone dome	1 1 1	2500	35-17.5k -3	92 4	15	100P	1/S	28x16x11	44	Adj. bass with removable woofer mass.	
CM/530		150	reflex	8 8 1	cone pass. rad. dome	1 1 1	2800	36-17k -3	89 4	15	75P	1/C	24x14x12	35		
Kustom Acoustics Titan Labyrinth		1499	trans. line	12 5 1 1/4 1	cone cone dome dome	2 2 1 1	350 2500 7500	24-22k ±2.5	96 4	15	150C 500P	4/C	48x30x18	325	Opt. tilt & straight bases; fused.	
AEI-Amp Eater		1399	trans. line	12 5 1 1/4 1	cone cone dome dome	4 2 2 2	350 2500 7500	28-22k ±3	99 2-8	15	200C 800P	C	48x30x18	340	"	
TAS-Challenger		799	trans. line	12 5 1 1/4 1	cone cone dome dome	2 1 1 1	350 2500 7500	28-22k ±3	96 4	15	150C 500P	C	36x24x16	185	"	
Labyrinth		749	trans. line	12 5 1 1/4 1	cone cone dome dome	1 1 1 1	350 2500 7500	19-22k ±2.5	91 8	15	100C 300P	3/C	48x16x18	130	"	
Trapezoid		499	trans. line	12 5 1 1/4 1	cone cone dome dome	1 1 1 1	350 2500 7500	29-22k ±3	93 8	15	100C 300P	C	40x16x13	100	"	
Regency		349	trans. line	12 5 1 1/4 1	cone cone dome dome	1 1 1 1	350 2500	30-22k ±3	92 8	15	100C 300P	C	26x16x13	76		
Signet		259	trans. line	12 5 1 1	cone cone dome dome	1 1 1 1	700 2500	34-22k ±3	95 8	15	100C 300P	C	26x16x13	70		
Impulse		199	trans. line	12 5 1	cone cone dome	1 1 1	700 2500	39-21k ±3	92 8	15	100C 300P	C	24x14x9	48		

Manufacturer and model		Price (\$)	Enclosure type	Driver type	Driver size (in.)	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz - dB)	Sensitivity (SPL in dB at 1 meter w/ 1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (number/type)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
Lafayette Radio Electronics																
Criterion 3003		300	air susp., pass. rad.	12	cone	1	2000	30-25k \pm 3	91	6	20	180C	1/C	39x15x15	65	
Criterion 3002		240	air susp., pass. rad.	10	pass. rad. Heil AMT	1	2000	35-25k \pm 3	90	6	20	160C	1/C	39x12x14	55	
Criterion 3001		200	vented	10	cone	1	2000	40-25k \pm 3	89	6	15	150C	1/C	25x15x15	45	
Criterion 2003A		200	reflex	15	cone	1	900	20-20k	95	8	15	120C 200P	2/C	29x18x13	60	
Criterion 2002A		160	reflex	12	horn	1	2000	20-20k	96	8	10	90C 180P	2/C	26x16x14	50	
Criterion 2001A		120	reflex	10	ring	2	2000	30-20k	96	8	10	70C 140P	2/C	25x15x14	42	
Lancer Electronics																
BB-3		550	vented	12	cone	1	100	18-22k \pm 3	-	8	20	100C 160P	2/C	woofer: 18x21x21 satellites: 12x8x7	118	3-unit system.
PA-20		450	vented	5	cone	1	1000	20-22k \pm 4.5	-	8	20	75C 120P	2/C	39x18x13	78	"Phase-aligned."
SC-8		360	vented	12	dome	1	4000	20-22k	-	8	10	75C 120P	2/C	28x18x13	65	"
SC-7A		280	air susp.	12	cone	1	500	20-20k	-	8	10	75C 120P	2/C	26x15x12	59	
SC-9T		250	air susp.	10	dome	1	500	20-22k	-	8	10	50C 90P	2/C	38x12x12	62	Omnidirectional.
SC-4A		200	air susp.	12	dome	1	500	20-20k	-	8	10	50C 90P	2/C	24x15x13	53	
SC-10A		130	air susp.	10	dome	1	2500	20-20k	-	8	10	50C 90P	1/C	20x13x10	33	
9535-2		100	air susp.	12	cone	1	3000	30-20k	-	8	5	35C 50P	-	25x14x12	33	
Leak																
3090		870	trans. line	15	cone	1	350	35-26k \pm 3	88	6	-	100C 160P	2	47x20x15	112	2-pc. encl. w/ swivelling top; casters.
3080		550	air susp.	10	cone	1	450	38-22k \pm 3	85	8	12	80C	-	33x14x17	72	"Phase-compensated."
3050		355	air susp.	6 3/4	dome	2	3500	48-22k \pm 3	85	8	12	50C	-	25x12x13	42	"
3030		230	air susp.	5 3/4	dome	2	4000	60-22k \pm 3	85	8	12	35C	-	21x10x11	24	"
3020		175	reflex	5 3/4	cone	1	3000	62-22k \pm 3	85	8	12	25C	-	17x8x11	16	As above, stepped cab.
Lentek																
S-4		640	air susp.	6	dome	1	2500	60-18k \pm 3	78	8	25	75C 100P	-	20x10x10	25	
Linn Products																
DMS Isobarik		p1920	Isobarik	12x9	cone	1	375	20-20k \pm 3	-	4	50	-	-	30x15x16	105	Top-fire midrange & tweeter.
LTC																
TX-5		550	air susp.	10	cone	1	2600	36-24k \pm 3	94	8	25	100C 150P	1/C	30x28x10	80	Circ. breaker; tweeter plot. circ.; swivel stand.
100		340	air susp.	10	cone	1	2600	36-22k \pm 3	94	8	25	80C 100P	1/C	39x13x12	61	
50		240	air susp.	10	dome	1	2600	36-20k \pm 4	94	8	25	80C 100P	1/C	27x15x12	47	
25		180	air susp.	10	dome	1	2600	40-18k \pm 4	94	8	25	60C 80P	1/C	24x14x12	40	
LTL Electronics																
TP 6953		150	-	6x9	cone	1	800	30-20k	-	8	5	80C 160P	-	-	14	
CP 693		150	-	3	cone	1	1500	30-20k	-	8	5	80C 160P	-	-	11	
TP 653		120	-	6x9	cone	1	800	40-20k	-	8	5	80C 160P	-	-	13	
CP 63		120	-	3	cone	1	1500	40-20k	-	8	5	80C 160P	-	-	10	
Magnepan																
MG-1		495	dipole	354 in. ² 67 in. ²	planar	1	2400	50-17k \pm 4	82	5	35	200P	-	60x22x2	30	Other sizes avail.
Morantz																
DS-940		400	infinite, vented	12	cone	1	750	30-22k \pm 3	90	8	15	150C	2/C	15x45x12	80	Choice of inf. baffle or vented operation via removable plug.

Manufacturer and model

Manufacturer and model	Price (\$)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (number/type, C=cont. variable, S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
DS-930	340	infinite, vented	12	cone	1	750	33-22k ± 3	90	8	15	125C	2/C	28x15x12	58	"
			5	cone	1	2300									
			1 1/2	—	1	5000									
DS-920	340	infinite, vented	12	cone	1	750	33-20k ± 3	90	8	15	125C	2/C	38x15x12	65	"
			5	cone	1	2500									
			1 1/2	—	1										
HD-880	320	infinite, vented	12	cone	1	750	30-22k ± 3	90	8	—	150C	2/C	40x16x12	79	"
			5	cone	1	2300									
			1 1/2	—	1	5000									
DS-900	280	infinite, vented	10	cone	1	750	35-20k ± 3	88	8	15	100C	2/C	28x15x12	55	"
			5	cone	1	2500									
			1 1/2	—	1										
HD-770	260	infinite, vented	12	cone	1	750	33-22k ± 3	90	8	—	125C	2/C	27x15x12	57	"
			5	cone	1	2300									
			1 1/2	—	1	5000									
HD-660	200	infinite, vented	10	cone	1	750	33-20k ± 3	88	8	—	100C	2/C	24x15x12	45	"
			5	cone	1	2500									
			1 1/2	—	1										
7 MK II	160	infinite	12	cone	1	800	35-20k ± 3	88	8	15	200C	2/C	26x14x12	49	"
			5	cone	1	2500									
			1 1/2	—	1										
HD-550	150	infinite, vented	8	cone	1	800	40-20k ± 3	88	8	—	75C	2/C	23x13x10	33	As per DS-940.
			5	cone	1	3000									
			1	—	1										
6 MK II	120	vented	10	cone	1	2500	35-20k ± 3	88	8	15	125C	1/C	26x15x12	46	"
			1 1/2	—	1										
			1 1/2	—	1										
5MK II	100	infinite	8	cone	1	2500	40-18k ± 3	88	8	10	60C	1/C	23x12x10	32	"
			1 1/2	—	1										
			1 1/2	—	1										
HD-440	90	infinite	8	cone	1	2000	40-18k ± 3	87	8	—	50C	—	19x11x19	25	"
			3 1/2	—	2	8000									
			3 1/2	—	2										
Martin Speakers Div. Eastern Sound Sound Tower	449	air susp.	8	cone	4	1000	38-18k ± 5	95	8	50	100P	2/C	52x16x10	90	"
			5	dome	1	5000									
			—	horn	4										
Magnificat	429	air susp.	12	cone	2	500	26-22k ± 5	93	4	50	100P	2/C	38x18x14	90	"
			5	dome	2	4000									
			—	dome	2										
Gamma 1500	379	air susp.	15	cone	1	500	26-20k ± 4	92	8	25	60P	2/C	71x43x38	59	"
			5	cone	1	4400									
			3	—	4										
Gamma 1200M	339	air susp.	12	cone	1	600	25-20k ± 3	91	8	25	60P	2/C	71x38x31	53	"
			5	cone	1	5000									
			4	—	1										
Gamma 412	269	air susp.	12	cone	1	750	30-18k ± 3	92	8	20	55P	2/C	64x36x30	48	"
			5	cone	1	4400									
			3	—	2										
Gamma 310	179	air susp.	10	cone	1	1000	35-18k ± 3	93	8	15	50P	2/C	54x31x25	33	"
			5	cone	1	4500									
			3	—	1										
Gamma 308	119	air susp.	8	cone	1	1000	40-18k ± 4	92	8	15	45P	2/C	54x31x18	26	"
			5	cone	1	5000									
			4	—	1										
Gamma 208	99	air susp.	8	cone	1	1500	40-18k ± 5	92	8	15	40P	1/C	45x26x24	22	"
			4	—	1										
			4	—	1										
Matrecs Industries MA-254	255	air susp.	15	—	1	1000	25-24k	—	8	20	65C 70P	—	—	65	"
			10	pass. rad.	1	6000									
			4 1/2	cone	2										
MA-224	212	air susp.	3 1/2	piezo	1										"
			1 1/2	ring	1										
			12	cone	1	1000	30-24k	—	8	10	50C 55P	—	—	50	
MA-203	166	air susp.	4 1/2	cone	1	6000									"
			3 1/2	piezo	—										
			10	cone	1	1000	30-22k	—	8	5	40C 45P	—	26x15x11	32	
MA-123	90	air susp.	4 1/2	cone	1	6000									"
			2 1/2	—	1										
			12	cone	1	1000	35-22k	98	8	8	45C 50P	—	24x15x10	29	
Mc Intosh Laboratory XR7	999	air susp.	12	cone	2	250	20-20k *	90	8	30	200P	—	40x20x15	125	* Response with Mc Intosh equalizer; fused.
			8	cone	1	1400									
			2 1/2	dome	4	7000									
ML-2	799	air susp.	12	cone	2	250	20-20k *	90	8	30	100P	—	29x28x21	144	"
			8	cone	1	1500									
			2 1/2	dome	1	3000									
XR6	750	air susp.	12	cone	2	7000									"
			8	cone	1	250	20-20k *	89	8	30	200P	—	36x18x13	81	
			1 1/2	dome	1	1400									
XR5	499	air susp.	12	cone	1	250	20-20k *	89	8	30	200P	—	30x15x12	76	"
			8	cone	1	1400									
			2 1/2	dome	2	7000									

Manufacturer and model		Price (\$)	Price (\$ per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz)	Sensitivity (SPL in dB at 1 meter w/ 1W)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (C=cont. P=peak)	Dimensions (H x W x D in.)	Weight (pounds)	Remarks
XR3		425	air susp.	10 5 2 1/2	cone cone —	1 1 2	700 1400 7000	20-20k *		89	8	30	200P	—	27x13x12	60	"
ML-10C		319	air susp.	10 2 1/2 1 1/2	cone dome dome	1 1 1	1000 7000	20-20k *		89	8	30	100P	—	25x13x13	58	"
Mesa Electronics Sales 120		259	vented, pass. rad.	12 8 5 3	pass. rad. cone cone dome	1 1 1 1	65 600 4000	38-19k		93	8	15	120C 160P	2/S	28x16x13	55	Circ. breaker.
80		209	vented, pass. rad.	10 8 5 3	pass. rad. cone cone dome	1 1 1 1	65 600 4000	42-19k		93	8	15	80C 120P	2/S	25x14x12	45	"
60		159	vented, pass. rad.	8 6 1/2 5 3	pass. rad. cone cone dome	1 1 1 1	80 2500	45-19k		92	8	15	60C 100P	1/S	23x13x11	32	"
40		109	vented, pass. rad.	6 1/2 6 1/2 3	cone pass. rad. dome	1 1 1	85 3000	50-19k		95	8	15	90C 75P	1/S	21x12x10	23	"
30		109	air susp.	4 1	foam susp. dome	1 1	3500	60-25k		—	4	10	30C 50P	1/C	7x5x4	4	
Micro-Acoustics FRM-1A		200	air susp.	10 1 1/8	cone dome dome	1 4 1	1700	32-18k ±4		—	8	18	100C 200P	2/C	26x15x13	40	Angled tweeter array.
FRM-2A		159	air susp.	10 1 1/8	cone dome	1 3	1750	40-16k ±4		—	8	10	75C 150P	1/C	26x15x12	34	
FRM-3		124	twin vented	8 1 1/2	cone dome	1 1	2500	45-15k ±4		—	8	7	50C 100P	1/C	22x13x10	26	
Mirsch OM3-29		375	air susp.	8 1/2 4 1/2 1	cone cone dome	1 1 1	700 4000	35-20k		—	8	20	50C 100P	1/C	32x55x31	37	Side firing ambience driver.
OM3-38		330	air susp.	10 2 1	cone — dome	1 1 1	500 4500	30-20k		—	8	20	70C 150P	—	31x56x32	37	
OM3-100		300	air susp.	10 2 1	cone cone dome	1 1 1	700 5000	30-20k		—	8	15	100C	1/C	38x56x26	35	
OM3-28		240	air susp.	8 1/2 4 1/2 1	cone cone dome	1 1 1	700 4000	35-20k		—	8	20	50C 100P	—	25x51x32	27	
OM2-20		120	air susp.	8 1	cone dome	1 1	5000	45-20k		—	8	10	60C	—	27x47x21	15	
OM2-21		120	air susp.	8 1/2 1	cone dome	1 1	3500	40-20k		—	8	10	60C	—	25x46x29	22	
OM3-30		120	air susp.	8 1/2 4 1/2 1	cone cone dome	1 1 1	700 4000	35-20k		—	8	15	100C	—	34x50x23	27	
Mitsubishi DS50C5		460	reflex	12 5 1	cone cone dome	1 1 1	600 5000	25-20k		92	6	30	80P	S	35x17x16	77	Front controls.
DS40CS		360	reflex	12 2	cone cone	1 1	1500	30-20k		92	8	25	80P	S	33x16x16	70	"
DS358		280	air susp.	12 4 1 1/8	cone cone dome	1 1 1	800 5000	35-20k		91	6	25	80P	S	26x14x13	46	"
DS28B		200	air susp.	10 4 1 1/2	cone cone dome	1 1 1	800 5000	40-20k		91	6	25	80P	S	23x14x11	33	"
DS25B		150	air susp.	10 2	cone cone	1 1	1500	45-20k		90	6	20	60P	S	23x13x12	30	"
Monitor Audio MA3 Series II		549	reflex	14x9	—	—	400 3500	40-19k ±2.5		86	8	60	120C 200P	—	28x14x13	60	Fused.
MA1 Series II		429	reflex	13x9	—	—	375 3000	45-19k ±3.5		85	8	40	100C 120P	—	30x14x15	60	Fused.
MA4		309	reflex	8 1	— dome	1 1	3200	45-18k ±2.5		85	8	15	75C 100P	—	24x13x11	36	
MA5 Series II		288	air susp.	8 1	cone dome	1 1	3300	50-19k ±3		84	8	20	50C 100P	—	22x12x10	26	
MA8		180	air susp.	6 1	cone dome	1 1	3400	45-20k ±3		84	8	15	40C 80P	—	16x9x8	18	
MA7		150	reflex	6 3/4	cone Mylar	1 1	3500	55-20k ±4		86	8	10	30C 10P	—	16x9x8	15	
Mordaunt-Short Pageant		479	reflex	8 1	cone dome	1 1	350	65-20k ±3		89	8	15	50C 100P	2/C	21x13x9	21	
Festival		339	infinite	8 3/4	cone dome	1 1	3500	75-20k ±3		89	8	10	45C 90P	—	18x11x7	14	
Carnival		269	infinite	8 2 3/4	cone cone	1 1	3500	85-17k ±3		88	8	10	40C 80P	—	16x10x6	12	
Nakamichi Research Slimline Reference Monitor		480	reflex	8 1	cone cone	1 1	2000	50-16k ±5		94	16	20	20C 60P	—	37x16x14	62	Fused.

Manufacturer and model	Price (\$)	(per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz ± dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (number/type): C=cont.; V=variable; S=switched	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
Norman Laboratories																
Nine	440	air susp.	10	cone	3	1500	35-20k ±3	— 4	—	70C	2/S	40x16x15	75			
			1	dome	3											
Ten	290	air susp.	10	cone	2	1500	40-20k ±3	— 4	—	70C	1/S	38x15x13	60			
			1	dome	2											
Seven	200	air susp.	12	cone	1	1500	40-20k ±3	— 8	—	50C	1/S	24x16x13	40			
			1	dome	2											
Eight	130	air susp.	10	cone	1	1500	45-20k ±4	8	—	35C	—	23x12x10	28			
			1	dome	1											
Normende-Sterling Hi-Fidelity																
804	180		8 1/4	cone	2	1000	30-20k	91 4-8	10	90C	—	26x14x9	29			
			4 1/2	cone	1	10,000										
			1	dome	1											
803	130		8 1/4	cone	1	7500	30-20k	92 4-8	7.5	50C	—	17x11x9	18			
			3 1/2	cone	1	10,000										
			1	dome	1											
802	100		8 1/4	cone	1	7500	40-20k	92 4-8	5	35C	—	17x11x7	15			
			1 1/2	cone	1											
Ohm Acoustics																
OHM F	600	air susp.	12	cone	1	—	37-19k ±4	82 3.7	75	—	—	44x18x18	75	Single omnidirectional Walsh driver.		
OHM H	325	vented, pass. rad.	8	cone	1	1700	32-20k ±4	86 4-8	10	—	1/S	27x15x11	54			
			2	ring	1	5000										
			1	dome	1											
OHM C2	250	vented	10	cone	1	1700	37-20k ±4	86 6-8	10	—	1/S	25x14x10	43			
			2	ring	1	5000										
			1	dome	1											
OHM D2	200	vented	10	cone	1	1700	37-19k ±4	86 6-8	10	—	1/S	25x14x10	42			
			2	ring	1											
OHM L	160	vented	8	cone	1	1700	42-20k ±4	87 4-8	8	—	1/S	20x12x10	35			
			2	ring	1	10,000										
			2	dome	1											
OHM E	100	sealed	8	cone	1	1700	65-19k ±4	86 8-6	7	—	1/S	22x12x7	20			
			2	ring	1											
Optonica																
CP-5151	400	—	12	cone	1	500	40-50k	— 8	20	90C	2/C	27x16x14	62	Triampable; 30-kHz filter.		
			2	dome	1	6000										
CP-2121	170	—	10	ribbon	1	1200	40-20k	— 8	10	35C	—	29x15x12	33			
			10	cone	1											
			3	pass. rad.	1											
				dome	1											
Onkyo USA																
240	250	air susp.	15	cone	1	700	45-20k ±5	93 8	20	100C	2/C	27x17x13	45	Carbon fiber midr. cone.		
			4	cone	1	4500										
			1	dome	1											
160	165	air susp.	12	cone	1	2000	50-20k ±5	91 8	15	80C	1/C	22x14x13	30			
			2 3/4	cone	1											
Panasonic																
SB1800	380	pass. rad.	10	cone	1	3500	—	— 8	5	60P	—	30x18x12	50			
			—	pass. rad.	1											
			—	horn	1											
SB1600	200	pass. rad.	10	cone	1	3000	—	— 8	5	40P	—	25x15x11	30			
			—	pass. rad.	1											
			2 1/4	—	1											
SB1100	170	pass. rad.	8	cone	1	5000	—	— 8	5	30P	—	22x13x8	25			
			—	pass. rad.	1											
			2 1/4	—	1											
SB350	100	pass. rad.	5 1/4	cone	2	5000	—	— 8	5	30P	—	22x13x8	25			
			—	pass. rad.	1											
Parenthian																
3600M	1899 (set)	—	15	cone	1	20-80	—	— 6	—	250C	—	—	—	3-unit system; 150W bass servo amplifier.		
			8	cone	4	500-800										
			2	dome	2	3000										
			—	planar	4	7000										
2400M	899	infinite	12	cone	2	150	30-22k ±3	— 8	30	150C	2/C	41x13x19	135			
			6	cone	2	150-750										
			—	radiator	2	750										
			—	diffraction	2	5000										
			—	—	—	5000+										
1200M	400	—	12	cone	1	500	30-20k ±3	— 8	25	60C	2/C	24x16x11	48			
			5	cone	1	500										
			1	dome	1	3000										
DBM100	299	air susp.	10	cone	2	700	17-27k	— 8	10	100C	3/C	44x15x13	84			
			4 1/4	cone	1	6000										
			—	piezo	1	11,000										
DBM-50	179	air susp.	12	dome	1	800	22-27k	— 8	6	80C	2/C	24x14x12	47			
			4 1/4	cone	1	6500										
			—	piezo	1											
			—	horn	1											
DB-40	110	air susp.	12	cone	1	1400	28-19.5k	— 8	5	80C	2/C	24x14x12	32			
			4 1/2	cone	1	4500										
			1 1/2	ring	1											

Phase Linear
III

Philips

RH545

RH567

RH544

AH477

AH476

RH541

AH475

SJ2931

U.S. Pioneer Electronics

HPM-200

HPM-150

HPM-100

CS-99A

HPM-60

HPM-40

Project 100A

Plasmatronics

Hill type 1

Point 3 Systems

Point 3 System

Polk Audio

Model 10

Model 7

Model 5

Mini Monitor

Power Research

Products

System III-E

Manufacturer and model

Price (\$)		Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz)	Sensitivity SPL in dB at 1 meter w/1W	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (number/type): C=cont. variable; S=switched	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
1350 (set)	vented dipole	12 8 4 1 1	cone cone cone cone dome cone	2 4 4 8 2	100 600 3000 8000	24-22k ±3	80 6	100 350C 700P	3/C	63x24x5	223	4-way, 4-piece—two panels; subwoofer; variable equalizer.			
400	vented	12	cone cone	2 2	100	24-100 ±3	— 6	100 350C 700P	—	19x22x22	100	Subwoofer.			
1300	mot. fdback.	12 2 1 1	cone dome dome	1 1 1	500 3000	20-20k	— 4/8	— —	4	26x17x13	67	Triamplifier. 50W servo+35W+15W.			
430	mot. fdback.	10 2 1 1	cone dome dome	1 1 1	500 3500	27-20k	— 4/8	— —	—	21x13x11	—	Biampifier: 40W servo+20W.			
380	mot. fdback.	8 2 1 1	cone dome dome	1 1 1	500 4000	35-20k	— 4/8	— —	—	15x11x9	26	"			
300	air susp.	12 2 1 1	cone dome dome	1 1 1	1500 5500	32-20k	— 8	20 80C	2/S	28x15x15	54				
200	air susp.	10 2 1 1	cone dome dome	1 1 1	1500 5500	35-20k	— 8	20 60C	—	26x14x11	42				
200	mot. fdback.	7 1 1 1	cone dome dome	1 1 1	1400	35-20k	— 4	— —	—	9x12x7	20	25W servo-amp.			
110	air susp.	8 1 1 1	cone dome dome	1 1 1	3500	40-20k	— 8	10 40C	—	24x14x11	38				
p200	vented	10 4 2 1/4	cone cone cone cone	1 1 1 1	2500 8000	45-17.5k	— 8	— 35	—	27x15x13	39				
550	air susp.	10 2 1/2 —	cone dome HPM HPM	2 1 1 1	100 700 2000 5000	25-25k	89 6	50 100C 200P	3/S	32x29x19	—	Polymer film tweeter & super tweeter; carbon fiber cone woofer.			
500	reflex	15 1/4 1 1/4	cone cone cone horn HPM	1 1 1 1	750 2600 8500	25-40k	92.5 6.3	50 125C 300P	2/C	39x18x18	82	Polymer film omnidirectional super tweeter; carbon-fiber cone woofer.			
300	reflex	12 4 1 1/4	cone cone cone HPM	1 1 1 1	1200 4000 12,000	30-25k	92.5 8	50 50C 200P	2/C	26x15x16	59	Polymer film super tweeter; carbon fiber cone woofer.			
275	infinite	15 5 4 —	cone cone cone horn HPM	1 1 1 1	800 2000 5000 10,000	25-22k	97 8	10 100P	2/S	25x17x11	52				
225	reflex	10 4 1 1/4	cone cone cone HPM	1 1 1 1	1200 4000 12,000	35-25k	92.5 8	30 30C 120P	2/C	24x14x13	39	As per HPM-100.			
150	reflex	10 1 1/4 —	cone cone cone HPM	1 1 1 1	4000 10,000	35-25k	91 8	20 20C 100P	1/C	23x13x13	29	"			
125	reflex	10 2 2	cone dome cone	1 1 1	700 6000	40-20k	91.5 8	10 30C 60P	—	23x13x11	30				
p5990	—	12 5 —	— — plasma	1 1 1	100 700-1000	—	— —	— —	—	58x25x19	150	Ionized gas discharge (plasma) & Class A tube amp for HF; requires 1 tank helium ea. 300-500 hrs. play; "low tank" tight.			
400 (set)	air susp.	10 5 1	cone cone dome	2 2 1	125 5000	20-20k ±3	90 8	15 100C 200P	—	15x24x14	—	3-pc system—2 satellites & subwoofer; "time-aligned" midrange & tweeter.			
210	fluid coup.	10 6 1/2 1	cone cone dome	1 2 1	60 3000	30-20.5k ±2	96 6	10 100C 200P	—	28x6x12	50				
150	fluid coup.	8 6 1/2 1	cone cone dome	1 1 1	60 3000	33-20.5k ±2	94 8	10 60C 100P	—	24x14x9	36				
110	fluid coup.	8 6 1/2 1	cone cone dome	1 1 1	60 3000	40-21k ±3	92 8	10 60C 100P	—	22x7x9	29				
100	fluid coup.	4 1/2 1	cone cone dome	2 1 1	100 3000	60-20.5k ±2	92 6	5 30C 80P	—	—	20				
840	ventless duct	12 6 3 1	cone cone — piezo	1 4 8 1	55 275 3000	26-22k ±4	85 4	60 350C 500P	1/C	45x16x16	110	Bidirectional.			

Manufacturer and model

	Price (\$)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz -dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (number/type; C=cont. variable; S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
	435	ventless duct	10 6 3 1	cone cone — piezo	1 1 1 1	75 400 4500	26-22k±4	83 8	60	120C 250P	—	39x19x12	70	"	
	310	ventless duct	10 5 1½	cone cone dome	1 1 1	85 800	32-18k ±4	85 8	40	80C 150P	—	34x14x12	45	"	
	170	ventless duct	8 1½	cone dome	1 1	900	40-16k ±4	84 8	25	40C 80P	—	32x12x9	25		
	495	reflex	8 1	cone dome	1 1	1500	30-20k ±2.5	84 4	50	85C 150P	2/S	23x12x11	35	Motional feedback w/any amp.	
	280	pass. rad.	8 10 1	cone pass. rad. dome	1 1 1	2000	70-20k±2	— 8	20	60C	—	30x14x13	40		
	200	pass. rad.	7 8 1	cone pass. rad. dome	1 1 1	2000	70-20k ±2	— 8	15	50C	—	26x12x10	30		
	170	reflex	8 1	cone dome	1 1	1500	70-20k ±3	— 8	12	40C	—	20x11x10	25		
	100	reflex	7 1	cone dome	1 1	1500	85-20k ±3	— 8	10	30C	—	15x9x8	15		
p3000	air susp. air susp.	14 8 4½ 2	— — — —	— — — —	1 1 1 1	70 700 2500 5000	29-90k ±3 55-22k ±3	88 8 88 8	150 150	— —	— 1/S	25x28x17 18x13x8	110 27	1 subwoofer + 1 full-range each channel; cross-over freqs. overlap.	
p1000	—	¾ 3¾	ribbon	1	1	—	4k-60K ±3	92 4	10	10C 40P	—	5x3x8	15	Tweeter only.	
	300	air susp., trans. line	15 6 —	— dome	1 1 1	250 3000	28-22.5k ±4	— 8	10	—	2/C	40x13x19	90	Fused.	
	230	air susp., trans. line	12 6½ —	— dome	1 1 1	500 3000	32-22.5k ±4	— 8	10	—	2/C	26x13x15	60	Fused.	
	170	—	10 6½ 2½	— — —	1 1 1	600 3000	38-20k ±4	— 8	10	—	2/C	25x12x14	52	Fused.	
	130	air susp.	10 2½	— —	1 1	1500	45-20k ±4	— 8	10	—	none	23x11x13	30	Fused.	
	99	air susp.	8	—	1	1500	55-20k ±4	— 8	10	—	none	21x10x12	37	Fused.	
	425	—	8 4½ 2 1	cone — cone dome	2 1 1 1	800 3000 8000	28-22k +2, -5	92 6	30	50C 120P	3/C	48x13x10	65	Takes less than 1 ft².	
	199	—	8	cone	2	90	28-100 +2, -5	— 6	30	100	none	34x12x10	50	Center-channel bass unit for use with TAD or Micro. Separate channel drivers.	
	179	—	4 2 1	cone cone dome	2 1 1	2000 8000	40-20k	89 15	—	30C 100P	1/C	25x8x7	23	"	
	89	—	3 1	— cone	2 1	3000	80-18k +2, -5	80 6	8	20C 60P	none	11x5x4	15	"	
	200	air susp.	15 —	— 4-cell horn	1 1	900 5000	20-25k	88 8	—	100	2/S	28x18x12	50		
	150	air susp.	8 3	— cone	2 1	3500	55-18k ±3	90 8	—	75	2/S	35x13x12	38		
	140	pass. rad.	8 10 3¾	— pass. rad. dome	1 1 1	3000	42-20k ±3	88 8	—	75	1/S	25x15x10	—		
	130	air susp.	12 4	— cone dome	1 1	1300 6000	45-20k	— 8	—	60	2/S	25x14x12	—		
	120	air susp.	12 3 3	— — —	1 2 1	1500 8000	40-20k	87 8	—	75	2/S	25x14x11	37		
	170	air susp.	10 3	— —	1 2	2000	45-20k	87 8	—	55	1/S	22x12x11	30		
	100	air susp.	10	—	1	1200	58-18k	88 8	—	70	1/S	22x12x11	23		
	350	air susp.	12	cone	1	—	—	— —	—	100	—	21x37x21	118	Subwoofer.	
	400	reflex	12 5 —	cone cone horn	2 2 1	800 5000	25-20k	— 4	10	200C	2 C	46x18x11	90	"Twin sub-enclosure", fused.	
	300	reflex	12 5 1	cone cone dome	1 1 1	800 4000	30-20k	— 8	12	125C	2 C	32x18x12	60	Fused.	

Manufacturer and model		Price (\$)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (number/type)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
RSL 3300	reflex	250	12 5 1	cone cone dome	1 1 1	800 5000	40-20k		- 8	10	100C	2 C	25x15x12	49	Fused.	
RSL Ranger	reflex	200	10	cone	1	800	42-20k		- 8	15	80C	2 C	25x15x12	39	Fused	
RTR DR-1 Dymstatic	see "remarks"	1290	12 10	cone cone	1 2	30-20k ±3 375			- -	75	125C 250C	- -	- -	-	-	Subwoofer section of 2-piece system "negative environment enclosure." Circular tweeter array powered by special amp. in woofer cabinet. Circuit breaker.
			-	elect	27	375			- -	-	-	-	49x17x17			
HPR-12 Magnum	pass. rad.	335	12 12 5 - 2 3	pass. rad. cone - piezo	1 1 1 2 1	500 7500	30-25k		- 8	15	100	2 C	36x15x13	-		
600-D		450	12 1													

Sonab

OA 2212

OA 116

OA 14

OA 12

OD 11

Sonic Energy Systems

TA-12P

TA-10P

TA-10F

TA-10

Sonic Systems

Monolith

Monitor

Sony

SS-67

SSU-4000

SSU-3000

SSU-2000

SSU-1250

Speaker Kit

Eleven

Ten

Six

Five

Four

Three

Speakerlab

K

Super Seven

Seven

Six

Four

Three

Two-and-a-Half

Two

Price (\$)		Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz - dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level control (number/type)	C-cont. variable (S-switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
840	reflex	6 1/2 6 1/2 1 3/8	cone cone —	2 2 12	450 2000	30-15k ±3	— 8	15	100C	yes	30x12x21	72	Multi-directional; sold in matched pairs only; tweeter level controlled ±1.5 dB by jumper.			
520	reflex	6 1/2 6 1/2 1 3/8	cone cone —	1 1 6	500 1800	28-15k ±3	— 8	15	100C	yes	16x11x18	47	"			
315	reflex	6 1/2 6 1/2 1 3/8	cone cone —	1 1 4	1800	29-15k ±3	— 8	15	80C	yes	12x9x17	25	"			
240	reflex	6 1/2 6 1/2 1 3/8	cone cone —	1 2 1	1800	42-15k ±3	— 8	15	70C	yes	18x8x13	15	"			
180	reflex	6 1/2	cone	1	1800	52-15k ±4	— 8	15	60C	yes	10x10x10	12	As above, but for floor or bookshelf mounting.			
400	vented	12 4 1/2 1	cone cone dome	1 1 1	600 6000	38-18k ±3	86 8	8	40C 400P	1/C	44x22x12	85	"Time aligned."			
340	vented	10 4 1/2 1	cone cone dome	1 1 1	800 6000	43-18k ±3	86 8	8	25C 250P	1/C	40x20x12	75	"			
250	pass. rad.	10 10 1 1/2	cone pass. rad. dome	1 1 1	600 1800	40-17k ±3	87 8	10	25C 250P	1/C	39x15x12	70	"			
160	vented	10 10 1 1/2	cone cone dome	1 1 1	1800	70-17k ±3	87 8	10	25C 250P	1/C	24x13x12	47	"			
p2995	reflex	15 —	— compression	2 4	1200	33-18k ±4	97 4	5	300C 600P	C	46x27x24	200	Bi-ampable.			
p1195	reflex	12 —	— compression	1 1	1200	45-18k ±4	92 8	10	100C 250P	C	31x17x15	70	"			
1000	reflex	15 4 1 1/2	cone cone —	1 1 1	550 4500	30-20k	94 8	—	180C 200P	2/C	20x37x18	106	In-line drivers; non-reflecting front panel.			
400	pass. rad., reflex	10 9 3 1/2	cone pass. rad. —	1 1 1	500 5500	30-20k	91 8	20	100C	2/C	47x14x15	71	"			
300	vented	10 3 1/2 1	dome cone cone	1 1 1	600 5500	35-20k	91 8	10	75C	2/C	34x14x15	60	"			
150	air susp.	10 2 1/2 1	dome cone cone	1 1 1	2500	35-20k	90 8	20	50C	1/C	4x13x14	38	"			
100	pass. rad., reflex	8 8 2 1/2	cone cone pass. rad. cone	1 1 1 1	4000	45-20k	90 8	10	30C	—	25x14x12	24	"			
400	vented	15 —	cone horn	1 1	800 4000	34-15k ±3	103 8	5	50C 500P	2/C	48x25x16	130	Kit; also avail. w/o encl.			
340	vented	12 —	cone horn	1 1	800 4000	37-15k ±3	100 8	5	25C 250P	2/C	48x20x16	117	"			
255	air susp.	15 7 2 1	cone cone dome dome	1 1 1 1	200 1600 5500	28-22k ±3	94 8	25	100C 200P	2/C	48x20x16	114	"			
170	air susp.	12 2 1	cone dome dome	1 1 1	800 4000	32-22k ±3	93 8	15	80C 175P	2/C	28x16x14	69	"			
130	air susp.	12 5 1	cone cone dome	1 1 1	500 4000	35-22k ±3	91 8	15	60C 150P	2/C	24x16x12	50	"			
113	air susp.	10 5 1	cone cone dome	1 1 1	500 4000	38-22k ±3	91 8	10	50C 100P	2/C	24x16x10	46	"			
630	horn	15 —	cone horn	1 2	400 5000	—	— 4/8	10	150C	2/C	50x32x28	220	Bass only.			
470	air susp.	12 10 —	cone cone horn	1 1 2	1200 6000	—	— 4	15	150C	2/C	29x18x15	86	Kit \$307; components \$261.			
400	air susp.	12 10 —	cone cone horn	1 1 2	1200 6000	—	— 4	15	150C	2/C	29x18x15	85	Kit \$243; comps. \$199.			
300	air susp.	12 —	cone horn	1 2	1200 6000	—	— 8	15	100C	2/C	28x16x12	65	Kit \$191; comps. \$167.			
270	air susp.	12 6 —	cone cone horn	1 1 1	400 4000	—	— 8	15	100C	2/S	28x16x12	65	Kit \$165; comps. \$140.			
240	air susp.	12 6 1	cone cone dome	1 1 1	400 4000	—	— 8	15	100C	2/S	28x16x12	65	Kit \$141; comps. \$115.			
185	air susp.	10 6 1	dome cone cone	1 1 1	500 3000	—	— 4	10	50C	2/S	24x15x12	52	Kit \$109; comps. \$83.			
145	air susp.	10 1 1/2	dome cone dome	1 1 1	1000	—	— 4	10	50C	1/C	24x16x12	49	Kit \$84; comps. \$58.			

Manufacturer and model		Price (\$)	(p-per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz - dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (number/type): C-cont. variable, S-switched	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
One	98	air susp.	8	cone	1	3000	—	—	4/8	5	40C	1/C	18x11x10	30	Kit \$54; comps. \$41.		
Point One	89	air susp.	6	cone	1	2500	—	—	4/8	10	40C	1/C	10x7x5	7	Kit \$54; comps. \$46.		
Spendor 8C3	770	reflex	12	cone	1	700	50-18k ±3	—	8	50	75P	—	32x16x16	75			
			8	cone	1	3000											
			1 1/4	dome	1	13,000											
8C-1	320	reflex	8	cone	1	3000	50-18k ±3	—	8	20	50P	—	25x12x12	31			
SA-1	200	infinite	1 1/4	dome	1	13,000											
			3/4	dome	1	3000	65-18k ±3	—	8	20	40P	—	12x9x9	16			
Synergistics S72A	600	air susp.	10	cone	2	1000	26-24k	—	4	6	200P	2/C	42x27x11	103	Angled tweeter array; circ. bkr.		
			4 1/2	cone	2	7500											
			2 1/2	—	3	12,500											
S62A	400	air susp.	12	piezo	1	1000	26-24k	—	8	8	150P	2/C	36x18x11	67	Circ. bkr.		
			4 1/2	cone	1	7500											
			2 1/2	—	3	12,500											
S52A	325	air susp.	8	piezo	1	3200	30-20k	—	4	8	150P	1/C	32x15x13	55	"		
			4 1/2	cone	1												
S51A	325	air susp.	12	cone	1	1000	30-24k	—	8	8	150P	2/C	26x14x12	42	"		
			4 1/2	cone	1	7500											
S42A	230	air susp.	10	piezo	1	1500	28-20k	—	8	10	100P	2/C	26x14x12	40	"		
			4 1/2	cone	1	7500											
S32A	170	air susp.	10	cone	1	2500	28-20k	—	8	10	80P	—	26x14x12	38	"		
			2 1/2	—	1												
S22A	130	air susp.	8	cone	1	3200	33-20k	—	8	6	60P	—	23x12x10	29	"		
			2 1/2	—	1												
S12A	100	air susp.	8	cone	1	3200	40-20k	—	8	6	60P	—	18x10x9	17	"		
			2 1/2	—	1												
Tamon TS707	380	infinite	15	cone	1	600	30-35k ±3	96	8	15	110C	S	27x17x12	55			
			—	cone	2	2500											
CR050	360	infinite	12	dome	2	15,000	32-22k ±3	93	8	15	45C	2/C	25x15x13	39			
			—	cone	1	800											
TS505	270	infinite	12	cone	1	700	32-35k ±3	93	8	15	80C	2/S	24x15x13	38			
			—	cone	1	2500											
CR040	250	infinite	10	dome	1	—	38-22k ±3	92	8	15	35C	1/C	23x13x13	28			
			—	cone	1												
TS404	230	infinite	10	dome	1	800	38-35k ±3	92	8	10	100P	1 S	22x12x13	28			
			—	cone	1	2500											
CR030	140	infinite	8	dome	1	3000	45-22k ±3	90.5	8	15	25C	—	18x10x11	16			
			—	cone	1												
TS303	140	infinite	8	dome	1	3000	45-22k ±3	92	8	10	40C	—	18x11x10	20			
			—	cone	1												
Tannoy-Ortofon Buckingham	2500	reflex	12	—	2	350	20-20k	95	8	10	200C	4 S	46x24x18	250	Coax. midrange tweeter.		
			10	—	1	3500											
Windsor	1450	reflex	2	horn	1	350	40-20k ±3	92	8	10	120C	4 S	32x22x16	125	"		
			10	—	1	3500											
Arden	588	reflex	15	cone	1	1000	30-20k ±4	—	8	10	85C	2 S	39x26x15	124	Coaxial.		
			2	—	1												
Berkeley	495	reflex	15	cone	1	1000	30-20k ±4	—	8	10	85C	2 S	33x21x12	90	"		
			2	—	1												
Cheviot	395	reflex	12	cone	1	1000	40-20k ±4	—	8	10	60C	2 S	33x18x10	66	"		
			2	—	1												
Devon	348	reflex	12	cone	1	1000	45-20k ±4	—	8	10	60C	2 S	23x16x10	46	"		
			2	—	1												
Eaton	295	reflex	10	cone	1	1000	50-20k ±4	—	8	10	50C	2 S	21x14x10	40	"		
			2	—	1												
Technics by Panasonic SB-7000A	420	vented	13 1/2	cone	1	700	37-22k	90.5	6	—	150P	2 S	33x19x16	73	"		
			4 1/2	cone	1	6000											
SB-6000A	320	vented	1 1/4	dome	1	1800	39-22k	91	6	—	100P	1 C	33x17x13	55	"		
			12	cone	1												
SB-X50	p460	vented	1 1/4	dome	1	700	—	93	6	—	50C	2 C	24x13x11	35	"Linear-phase"; stepped cab.; circ. brks.		
			3 1/2	cone	1	4500											
SB-5000A	170	vented	10	dome	1	1500	40-20k	92	8	—	75P	—	28x14x13	35	"		
			2 3/8	cone	1												
SB-X30	p340	vented	8	cone	1	700	—	93	6	—	40C	2 C	21x11x9	23	"		
			3 1/2	cone	1	4500											
			1 1/4	dome	1												

Manufacturer and model		Price (\$)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz - dB)	Sensitivity (SPL in dB at 1 meter w/ 1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts)	Level controls (C=cont; P=peak; S=switch)	Dimensions (H x W x D in.)	Weight (pounds)	Remarks
SB-4500	p300	vented	10	cone	1	2000	40-20k	92.5	6	—	50C	—	25x14x13	32	"	
			2 3/8	cone	1						75P	—				
SB-X10	p200	vented	8	cone	1	1500	—	90.5	6	—	30C	—	18x10x8	16	"	
			1 1/2	dome	1							—				
TransAudio 1012B	160	air susp.	12	cone	1	600	38-18k ±4	—	8	5	—	—	26x10x17	42		
			5 1/2	cone	1	2000						—				
1011B	105	air susp.	2 1/2	—	1							—				
			12	cone	1	1800	40-18k ±4	—	8	5	—	—	26x10x16	36		
Videoton D-258a	230	air susp.	10	—	1	600	30-20k ±3	—	8	15	60C	2/C	27x15x11	—		
			5	—	1	2000					120P	—				
D-402a	200	air susp.	1 1/2	dome	1	7000						—				
			8	dome	1						50C	—	28x15x11	—		
D-257a	150	air susp.	4	—	2	3500	35-20k ±3	—	8	15	100P	—				
			1	dome	2							—				
D-255	130	air susp.	10	—	1	1000	40-20k ±3	—	8	15	25C	1/C	24x12x12	—		
			5	—	1	4000					50P	—				
DP-202	80	air susp.	1	dome	1	4500	43-20k	—	8	15	55C	—	24x12x12	33		
			10	—	1						100P	—				
Visonik of America SU61/D502	590		8	—	1	3500	40-20k	—	8	10	50C	—	16x10x9	17		
			4	cone	1						100P	—				
D803	250	—	12	cone	1	160	16-30k +4, -8	—	6	50	300C	—	24x17x14	79		Subwoofer + 2 D502's (see below).
			4	cone	1	1400						—				
D702	200	—	3/4	dome	1	1100	16-30k +4, -8	—	4	20	120C	—	13x8x8	17		LED overload lite.
			8	cone	1	4500						—				
Euro 5	170	—	1 1/2	dome	1	2100	30-25k +4, -8	—	4	20	90C	—	—	14		
			7	cone	1							—				
D602	160	—	1	dome	1	1300	45-17k ±3	—	4	10	60C	—	19x11x10	24		
			8	cone	1							—				
D502	127	—	1	dome	1	1400	38-25k +4, -8	—	4	20	80C	—	9x6x6	9		
			5	cone	1							—				
D508L	110	—	1	dome	1	1400	45-30k +4, -8	—	4	20	70C	—	7x4x4	6		
			4	cone	1							—				
D302MO	92	—	3/4	dome	1	1800	48-25k	—	4	12	50C	—	7x4x4	5		
			3	cone	1							—				
Watson Laboratories 10	p1800	—	4	dome	1	2000	50-22k +4, -8	—	4	10	50C	—	7x4x4	5		
			2	cone	1							—				
7	p1300	—	10	cone	2	250	17-22k ±5	93	4	50	—	S	47x24x22	85		
			8	cone	1	800						—				
Wharfedale E-70	475	reflex	5	cone	2	6000						—				
			1 1/4	dome	1							—				
E-50	390	reflex	1	dome	2							—				
			10	cone	1	800	50-18k ±3	94	8	3	100C	2/S	32x14x14	70		
Dovedale SP2	355	reflex	4	cone	2	7000						—				
			1	horn	1							—				
Teesdale SP2	270	reflex	8 1/2	cone	1	800	55-18k ±3	94	8	3	70C	2/S	26x14x14	42		
			4	cone	2	7000						—				
Yamaha NS1000	725	air susp.	1	horn	1	800	35-26k ±3	88	6	—	60C	—	25x16x12	55		
			4	cone	1	5000					120P	—				
NS1000M	525	air susp.	2x1	planar	1	800	40-26k ±3	87	6	—	40C	—	23x14x11	31		
			8	cone	1	5000					80P	—				
NS690 II	310	air susp.	2x1	planar	1							—				
			12	cone	1	500	40-20k	90	8	20	50C	2/C	28x16x15	85		Beryllium-dome tweeters.
NS500	260	reflex	3 1/2	dome	1	6000					100P	—				
			1 1/8	dome	1							—				
NS325	220	reflex	12	cone	1	500	40-20k	90	8	20	50C	2/C	27x15x14	68		
			3 1/2	dome	1	6000					100P	—				
NS225	170	reflex	1 1/8	dome	1	800	35-20k	90	8	20	80P	2/C	25x14x12	59		
			3	cone	1	6000						—				
NS5	100	air susp.	1 1/8	dome	1	1800	40-20k	91	8	20	30C	1/C	24x13x13	42		Beryllium dome.
			10	cone	1						60P	—				

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Experiments with Programmable Logic Arrays

*Useful logic circuit has many applications
in waveform generation or digital control.*

BY KARL LUNT

THE Programmable Logic Array (PLA) is an important, little-understood electronic circuit which many experimenters would use more if they knew more about it. Described here, to help in such an understanding, is a circuit that can be used to generate a wide variety of output waveshapes with frequencies up to 15 MHz, with complete control over the output waveshape.

With some changes in the timing or

output circuit, the PLA can also serve as a switch and light controller for model train layouts, a digital controller and sequencer for simple machine or processing operations, a sophisticated timer-controller for use in a lab, darkroom, or kitchen, or even as an electronic "house-sitter" to control several appliances. This PLA can be built for about \$15—less if you have a well-stocked "junkbox."

The circuit consists of three elements: a timer and driver that converts a series of clock pulses into BCD information that selects an input line of the PLA matrix, the PLA itself (in this case a diode matrix), and the output circuit that includes the necessary interfaces to relays, lights, other TTL or a digital-to-analog converter.

Circuit Operation. The basic timer can be built around one of two circuits—a pair of conventional 555 timers as shown in Fig. 1 or the 555-7490 circuit shown in Fig. 2. The output frequencies of the 555's are dependent on their resistor-capacitor values and clock rates

can be as high as 1 MHz or as low as one pulse per minute.

The selected outputs of the clock oscillators can be used to drive a one-of-two selector like that shown in Fig. 3. The output of this circuit can be either clock-A or clock-B depending on the signal applied to control input C.

The main circuit shown in Fig. 4, accepts the selected clock output from IC1 and drives one or more decade counters

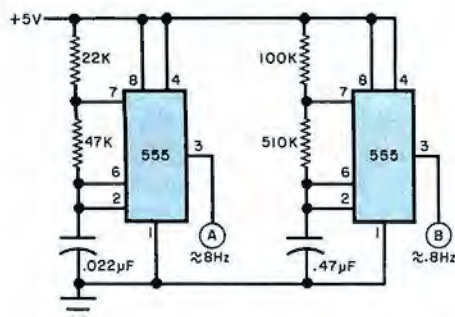


Fig. 1. Frequencies of either 555 can be from 1 MHz to one pulse per minute, depending on selected R and C values.

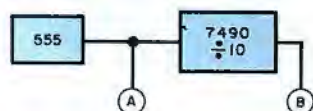


Fig. 2. The 555 drives decade counter in this clock. As many counters as desired can be added for ultra-slow clocks.

(IC2 is an example of one), and then the final decade counter IC3 whose outputs are BCD that count from 0 to 9 then automatically repeat.

The BCD outputs are applied to a 1-

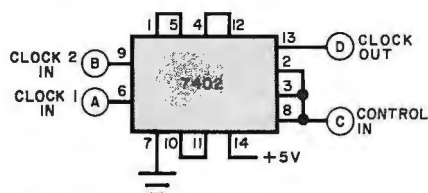
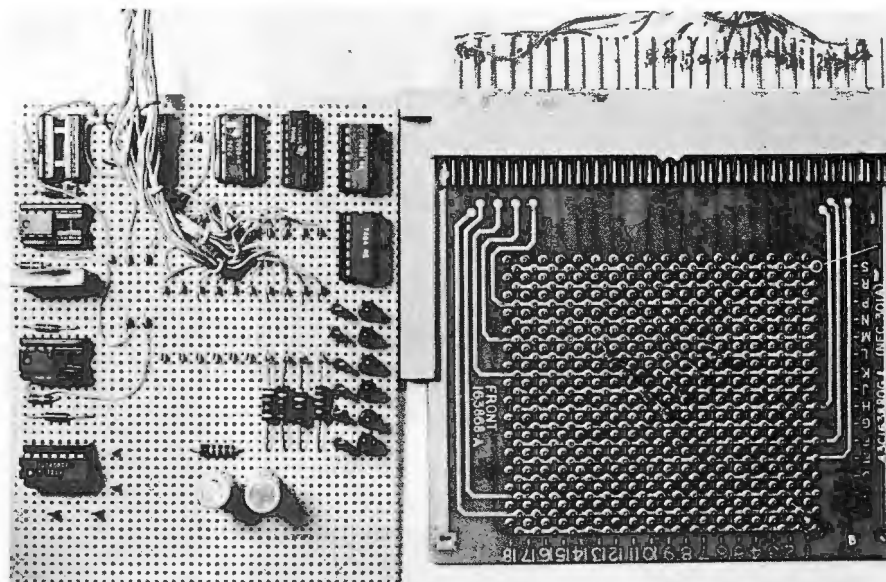


Fig. 3. A one-of-two selector allows PLA to control its own frequency. Output is A or B depending on control input C.

of-10 decoder (IC4) with each decoded output applied to a corresponding input line of the PLA—in this case, a 10 x N matrix. The 10 x N means that there are 10 inputs and any selected number (N) of outputs. In this matrix, the diode lines are driven low in sequential order by IC4 and a diode connected between the selected input and output lines will drive that output low. The outputs are fed to the inputs of the hex inverters within IC5 and IC6 that provide both inverting and buffering. The outputs of IC5 and IC6

Photo shows the author's prototype of complete PLA project. Diodes are on commercial matrix board at right. IC's and other electronics are on perf board.



can be used to drive other TTL devices, relay drivers, or, in the case shown in Fig. 4, a simple D/A converter that can be used to create various output wave-shapes.

Construction. Layout and lead dress are not critical so any type of construction can be used. Sockets are suggested for mounting the IC's.

The heart of the system is the diode matrix PLA that uses conventional silicon diodes (such as the 1N914) to form the matrix. In the prototype, a commercial pc board with a built-in 18 x 18 matrix of press-in terminals was used, although one can be built of conventional "flea clips" (or similar) with each horizontal (input) row interconnected and wired to its pin on IC4. Each vertical (output) column is built in a similar fashion and connected to the IC5-IC6 inputs. The selected diode clips should be capable of accepting the diode leads. The diodes are installed as shown in the matrix of Fig 4.

Either of the two oscillators can be selected, with any desired frequency used as the clock input.

The simple D/A converter shown in Fig. 4 consists of four resistors (although more can be added as the matrix is enlarged) that sum across R1. The voltage developed across these resistors is dependent on the placement of the diodes in the matrix. The square wave generated across R1 is smoothed by C1. The value of C1 can be changed as desired, or any other method of filtering can be used.

Once the basic circuit has been built, it should be powered and an oscilloscope used to make sure that all perti-

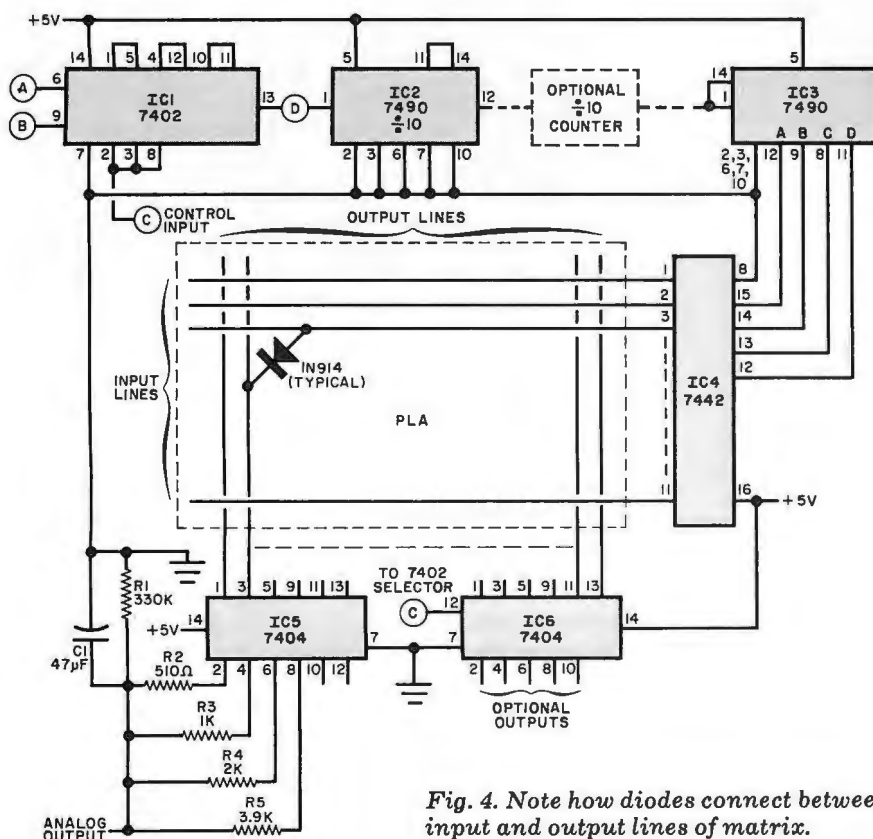
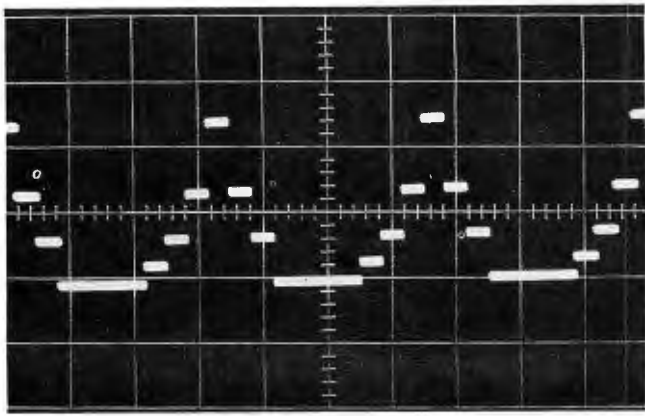


Fig. 4. Note how diodes connect between input and output lines of matrix.

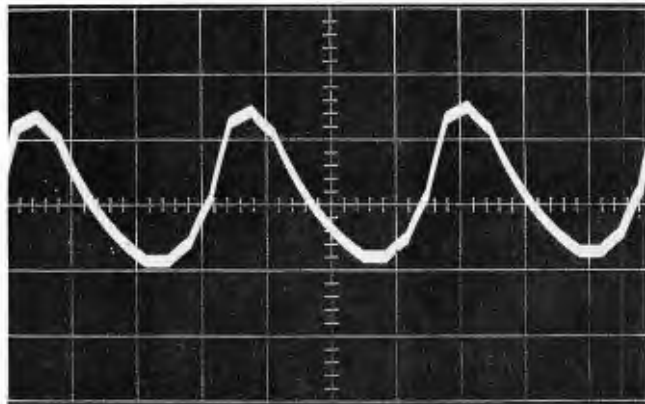
PARTS LIST

C1—47- μ F, 12-V nonpolar capacitor (two 100- μ F units connected in parallel)
IC1—7402 quad 2-input NOR gate
IC2, IC3—7490 decade counter
IC4—7442 1-of-10 decoder
IC5, IC6—7404 hex inverter
R1—330,000-ohm resistor

R2—510-ohm resistor
R3—1000-ohm resistor
R4—2000-ohm resistor
R5—3900-ohm resistor
Misc.—Perforated board, component mounting clips, sockets for IC's, matrix diodes (1N914), 555 timers and passive elements (see text), mounting hardware.

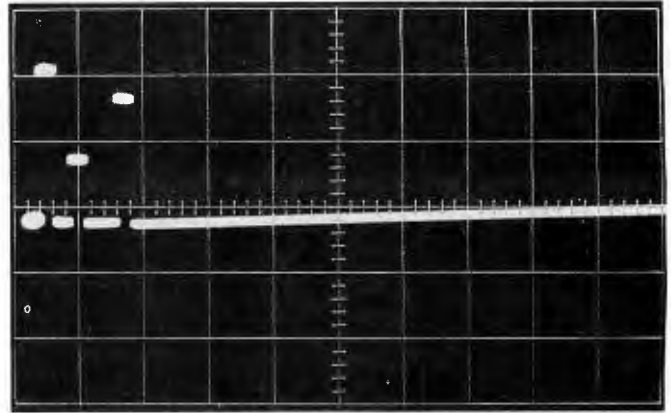


A

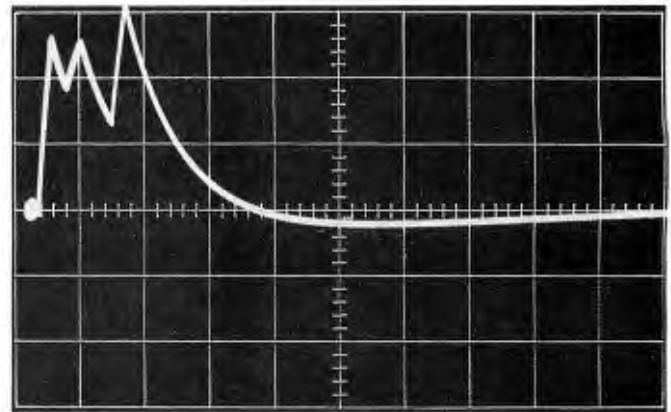


B

Oscilloscope photo (A) shows the output of the digital/analog converter with C1 (Fig. 4) removed at a frequency of 8 Hz. With C1 in, the output would form a sine wave such as that shown at (B). More elaborate filtering will smooth out the sharp edges. Waveform (C) shows how the PLA controls its own clock frequency. The first pulses are about 8 Hz followed by a 2.5-second delay until triggered again. Photo (D) is the PLA controlling its own frequency. The peaks inside the pulse are all 8-Hz rate, while the next pulse will not occur for more than 2 seconds.



C



D

nent waveforms are present and have the required fast rise and fall times suitable for TTL.

Use. There are two ways that the diode matrix can be used to control the output frequency. The simplest approach is to tie the "reset-to-zero" inputs (pins 2 and 3) of IC3 to an unused output line of the matrix and, if a diode is connected to this line, the circuit will recycle back to zero. The obvious disadvantage to this approach is that it becomes impossible to use any diode positions beyond the reset point.

The second method is to change the clock frequency coming from the driver circuits. A simple 1-of-2 decoder such as

the 7402 shown can be used to switch either one of two independent clocks (Fig. 1) or one of two frequencies derived from the same clock (Fig. 2). In the case of Fig. 1, the clocks may operate out of sync, therefore the clock in Fig. 2 may be used for more accurate timing. The control input of the 1-of-2 selector (Fig. 3) can be tied to an unused output line of the matrix, and the clock frequency that drives the system can be controlled using a diode on that particular line.

The system shown uses a 7490-7442 combination to produce a 10 x N matrix. If desired, a 7493-74154 combination can be used to produce a 16 x N matrix. The output waveform shape can be

changed by varying the value of filter capacitor C1 and the clock frequency. You can experiment with either of these values and observe the results.

It is possible to trigger the timing cycle with a pushbutton switch coupled to a monostable multivibrator. This allows the PLA to be used as an envelope generator in an electronic music system. It is also possible to generate two independent outputs from IC5 and IC6. Either output can be switch selected.

Although the circuit described is not presented as an actual construction project, it can be easily assembled, and the various parameters altered to create just about any reasonable output signal or waveform the builder can use. ◇

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Solid State

By Lou Garner

MOTOR CONTROL CIRCUITS

WITHIN industry, solid-state devices and circuits are used extensively for controlling and driving electric motors and other electromechanical actuators, including solenoids, linear drives and electric valves. Similar techniques can be just as valuable for a variety of hobbyist, experimenter and home projects. Typically, solid-state circuits can be used in constant- and variable-speed motor controls for toys, and household appliances such as mixers, stirrers, grinders and fans, workshop tools, including drills and sanders, and even in more sophisticated applications, such as tape recorders and computer floppy-disk drives. The range of potential applications, in fact, is virtually endless, limited only by the imagination, skill, and resources of the hobbyist.

Small dc motors of the type used in many toys can be controlled easily using a single low-to-medium-power transistor. A typical circuit is given in Fig. 1A. Here, the motor's current, hence its speed, varies as $Q1$'s base bias is adjusted by potentiometer $R2$. Although a pnp transistor is shown, an npn type can be used, if preferred, simply by reversing the battery and motor connections. Bypass capacitor $C1$ is optional, as is the fuse. If the transistor is used at or near its maximum ratings, a suitable heatsink should be provided to prevent overheating. In some applications it may be necessary to connect a small bypass capacitor (0.05 to 0.1 μF) across the motor terminals to reduce noise. Actual component values will depend, of course, upon the supply voltage, the transistor's

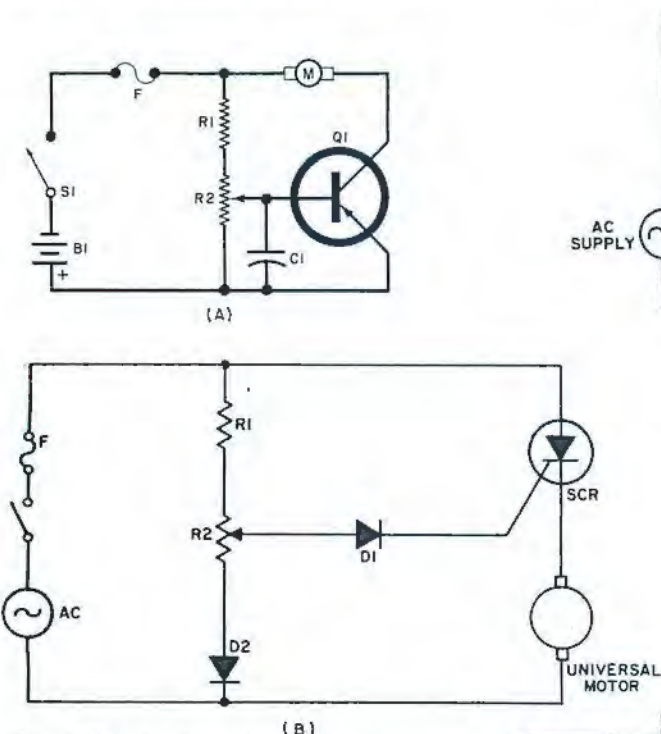


Fig. 1. Two basic motor control circuits. The one at (A) uses a transistor, while (B) is a circuit using an SCR for control.

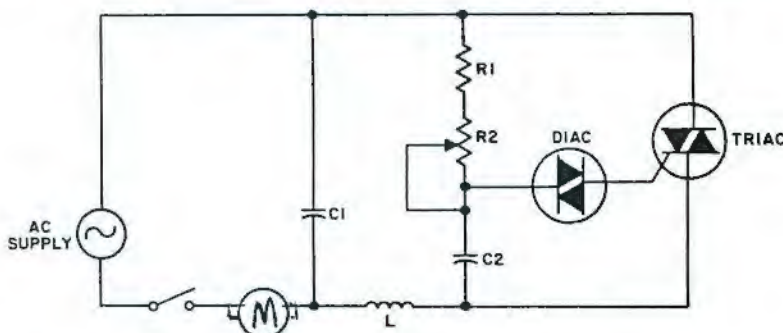


Fig. 2. A typical triac light-dimmer circuit that can also be used for motor control. Component values depend on specific devices used and intended application.

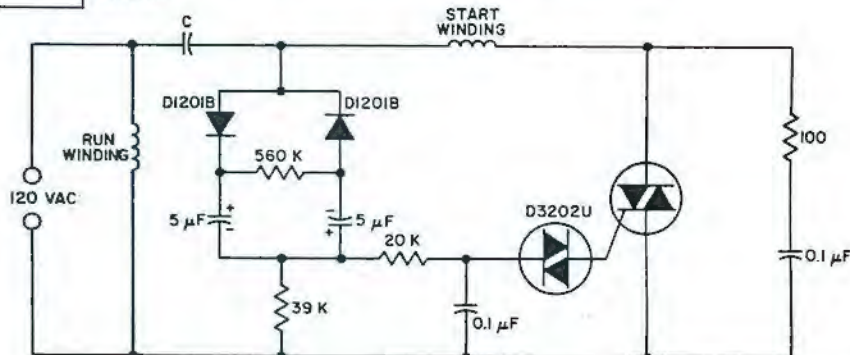


Fig. 3. Here solid-state devices are used in circuit of starting winding for medium and higher-power ac motor.

characteristics, the type of operation required, and the motor's rating. As a general rule, however, the values are not critical. Generally, $R1$ is chosen to limit $Q1$'s maximum base bias and thus its maximum collector current and the top motor speed, with $R2$, typically from five to twenty times $R1$'s value. If, for example, a 100-ohm resistor is used for $R1$, $R2$ might have a value from 500 to 2000 ohms. Similarly, if $R1$'s value is, say, 10,000 ohms, $R2$ might range from 50,000 to as much as 200,000 ohms. Where the motor's minimum as well as its maximum speed must be limited, a second fixed resistor can be connected between $R2$'s lower terminal and the power source, thus limiting its bias control range.

Line-operated "universal" (ac/dc) series motors of the type found in many home appliances and small power tools can be controlled effectively using the SCR circuit illustrated in Fig. 1B. Suggested by RCA in *Power Options from the Powerhouse* (publication No. 2M1169), the design uses two general-purpose diodes, an SCR, a fixed resistor ($R1$) and a control potentiometer ($R2$). As in the transistor circuit, the actual component values depend on the specific semiconductor devices used, the motor characteristics, and the mode of operation needed. RCA suggests SCR types S2060, S2061, and S2062 for motors requiring up to 4 amperes, type S2600 for requirements to 7 A, and type S2800 if as much as 10 A is needed. Again, heat sinking may be required.

As long as maximum ratings are observed, most triac light dimmer circuits also can be used as light-duty speed controls for household appliances and small power tools. A typical circuit was described in this column in December, 1977, and another is given in Fig. 2. As before, the component values depend on the specific devices used and the intended application (i.e., motor rating and desired control range). Typical values, however, are 0.1 μ F for $C1$ and $C2$, 100 μ H for L , 2.2k to 4.7k for $R1$, and 50k to 250k for $R2$. The diac may be type D3202Y or D3202U, while the triac may be types 2N5757, T2301 and T2302 for loads of up to 2.5 amperes, type T2500B for loads up to 6 A, and types 2N5571, 2N5572, T2800, T2850, T4100 and T4120 for requirements up to 15 A.

Unfortunately, not all ac motors are amenable to solid-state speed control. With synchronous and induction motors, for example, speed is essentially fixed and is determined by design and the

power-line frequency. Any variation from the design speed is caused by "slip-page" due to loading. Attempts to reduce speed by controlling the line voltage or current may result in a severe loss of torque and power, perhaps even causing a stall and burn-out.

Despite the limitations, solid-state controls can be used effectively for medium and higher power ac motor switching applications. Suggested by RCA, the motor-starting switch illustrated in Fig. 3 is a typical example. Suitable for medium-power motors operating on standard

household ac lines, the motor-starting circuit uses a triac as an automatic switch for the motor's start winding and its associated phase-shifting capacitor, C . The triacs used may range from types T2800 and T2850 for current requirements of up to 8 amperes to types 2N5567, 2N5569, and T4120 for loads of up to 15 A, or types 2N5441 and T6420 for currents of up to 40 A.

With the increasing popularity of solid-state motor controls, several semiconductor manufacturers have developed special IC's for such uses. The ICH8510/

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■ Selectivity:	-6dB @ ± 2 kHz or ± 4 kHz and -60dB @ ± 5 kHz or ± 14 kHz			
■ AM Harmonic distortion:	50% modulation = 0.6% T.H.D., 90% modulation = 1.5% T.H.D. (1kHz modulation)			
■ Frequency stability:	Within ± 40 Hz in any 8 hour period at a constant ambient of 25C, after 30 minute warm up.			
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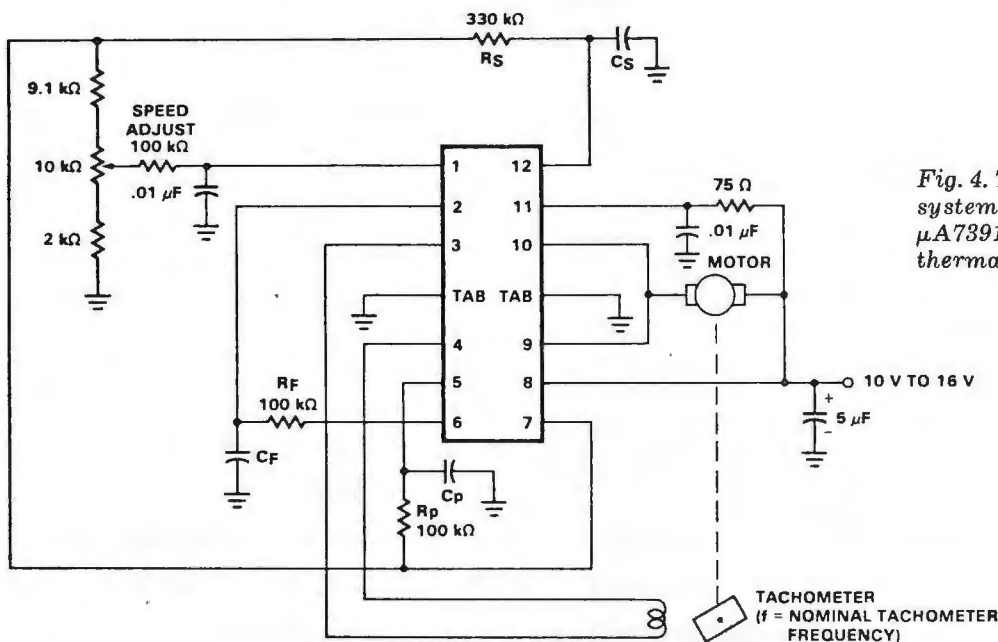


Fig. 4. Typical closed-loop system using the Fairchild $\mu A7391$ IC. The circuit includes thermal and overvoltage protection.

8520/8530 family offered by Intersil, Inc. (10710 N. Tantau Ave., Cupertino, CA 95014) is a representative example. Assembled in 8-pin TO-3 style metal cases, the devices are hybrid power amplifiers designed specifically for driving linear and rotary actuators, electric valves, push-pull solenoids, and ac or dc motors. Available for operation on dc supply sources

of up to ± 30 V, the ICH8510 will supply an output current of up to 1 A, the ICH8520 up to 2 A, and the ICH8530 up to 2.7 A. The devices are protected against inductive kickback by internal power limiting, have integral frequency compensation, offer an equivalent dc gain of better than 100 dB, and require a standby quiescent current of only 20 mA.

Manufactured by the Fairchild Camera and Instrument Corporation (464 Ellis Street, Mountain View, CA 94042), the $\mu A7391$ represents another type of motor-control IC. It is designed for precision, closed-loop, systems such as capstan drives in automotive and portable tape players, in floppy-disk drives for computer memories, and in data cartridge drives. Assembled in a 12-pin power package DIP with heavy heat-sink tabs, the device will deliver a motor starting surge current of up to 3.5 A and a running current of 2 A. It can be operated on dc source voltages from 6.3 to 16 V. Intended for use with an external motor driven tachometer generator, it will accept tachometer inputs from 100 mV to 1.0 V p-p. The device includes voltage regulator, pulse generator, comparator, thermal sensor, overvoltage sensor, and stall timing threshold and latch circuits as well as driver and power amplifier stages. In operation, the tachometer generator supplies an input signal proportional to motor speed. This signal is converted into fixed amplitude pulses and integrated by a standard R-C network before application to a comparator, where it is compared to a reference voltage representing the desired speed. The result of the comparison controls the duty cycle of the pulse width modulated switching motor drive output stage, thus closing the system's feedback loop and holding the motor speed to the rate established by the reference voltage. The thermal and overvoltage sensor circuits provide shutdown for self protection while the "stall timer" circuit protects the motor itself from burn-out during extended mechanical jams.

A typical application circuit featuring the $\mu A7391$ is illustrated in Fig. 4. The circuit component values will vary with the characteristics of the motor and tachometer used.

As a general rule, layout and lead dress are not critical factors when assembling and wiring motor-control circuits, although good wiring practice should be followed, with care taken to observe all dc polarities and to avoid overheating the

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semiconductor devices during installation. In addition, adequate heatsinks should be provided for the output drivers, whether transistors, SCR's, triacs, or IC's.

Readers' Circuits. Needing a visual indicator for his ac line-operated TRANSMIT/RECEIVE antenna relay, Ted Reiter (1442 Brook Drive, Titusville, FL 32780), replaced his standard spdt unit with a dpdt version, planning to use the extra contacts to control the indicator devices. After rejecting the use of neon lamps and short-lived incandescent types, Ted devised the circuit illustrated in Fig. 5. Permitting standard LED operation on the relay coil (ac line) voltage, Ted's design

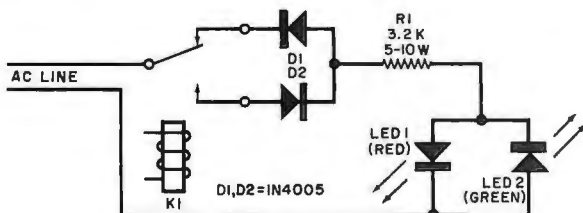


Fig. 5. Reader's circuit provides visual indication of whether relay is open or closed.

avoids the need for a step-down transformer, battery, or conventional dc power supply while retaining the low power and long life advantages offered by these devices.

Ted writes that virtually any LED's will work in his circuit, including low-cost "surplus" types, but warns that the series

dropping resistor, $R1$, gets rather warm during operation and should be mounted accordingly.

Edward C. Mauro (12 Pyramid Lane, Rochester, NY 14624) thinks readers may find his digital-logic automatic pump control circuit of interest and value. Used in conjunction with a transistorized relay to operate a water pump, Ed's circuit, Fig. 6, provides automatic level control for a water tank or sump. Ed writes that he uses his model to empty a dehumidifier tank

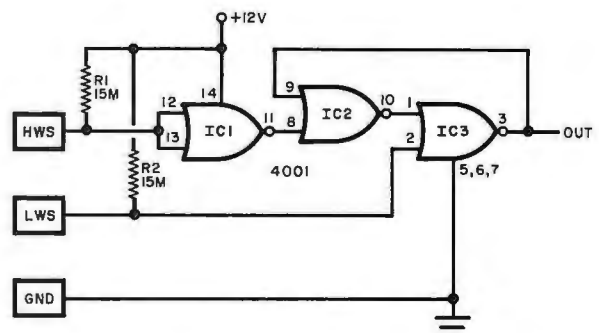


Fig. 6. Digital control circuit for a pump is controlled by level sensors.

automatically in the summer and to control the level in a furnace humidifier overflow holding tank in the TMS* winter.

Using standard CMOS 2-input NOR gates, the circuit's operation is straightforward and easy to follow. HWS and LWS are the high and low water sensors, respectively. When the

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water level is below both, IC3's output is low. As the water level rises past LWS, IC3's output remains low until HWS is reached. At this point, IC3's output goes high. Sensed by the transistorized relay, the high output switches the pump on. The water level starts dropping down past HWS, but IC3's output remains high due to the feedback loop to IC2, and the pump continues to operate. When the water level drops below LWS, however, IC3's output goes low and the pump shuts down completely.

Ed has specified inexpensive, readily available components in his design. The HWS, LWS and GND sensors are one-inch diameter sections of standard pc board (unetched). The LWS and GND sensors are suspended on insulated leads near the bottom of the tank, but above the pump intake level, while the HWS sensor is suspended at the desired pump "turn-on" level. The circuit may be assembled on perf board, a suitably etched pc board, or on a wirewrap breadboard, as preferred. It may be used with virtually any standard transistorized relay circuit compatible with CMOS output levels.

Device/Product News. Three new series of fast turn-off SCR's intended for high-speed switching applications such as power inverters, switching regulators, and high-current pulsing are now available from RCA's Solid State Division (Box 3200, Somerville, NJ 08876). Identified as the S5800, S5801, and S5802 series, the new devices may be used at frequencies of up to 25 kHz. Each series includes five types with voltage ratings ranging from 200 to 600 volts. The turn-off times for an 8-A load is 6 μ s for the S5800 series, 10 μ s for the S5801 series, and 15 μ s for the S5802 series. All the devices

are supplied in JEDEC TO-220A/B plastic packages.

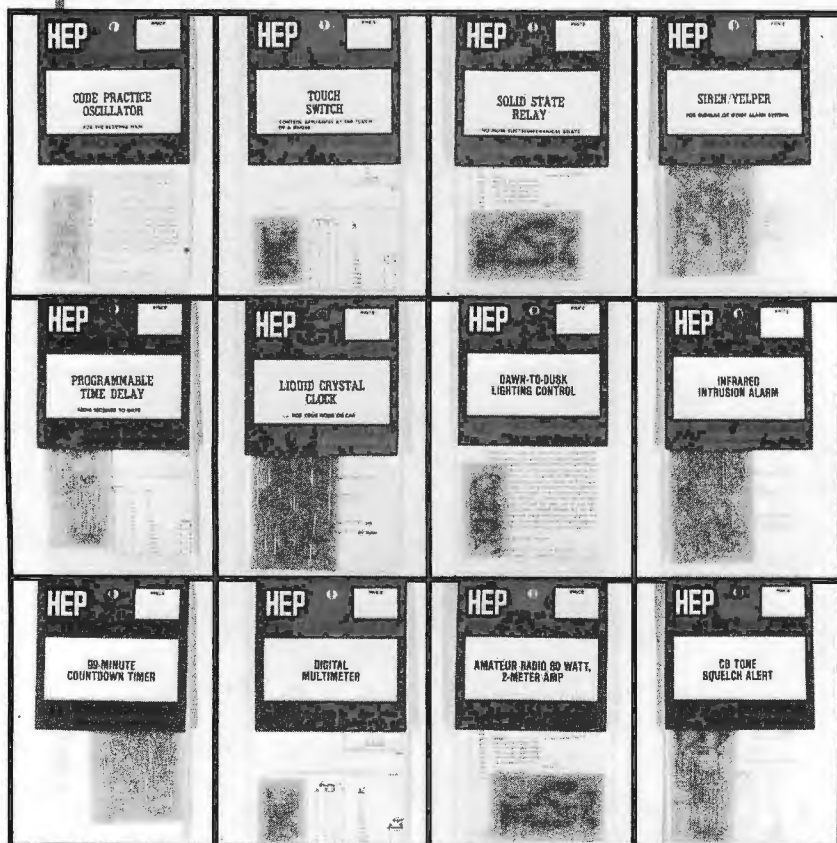
Motorola Semiconductor Products Inc. (P. O. Box 20912, Phoenix, AZ 85036) has added four new devices to its popular *Switchmode*® line of power transistors. Suitable for applications as motor controls, inverters, solenoid and relay drivers, and in deflection circuits, the new units include the 10-A types MJ13014 and MJ13015, with V_{ce0} ratings of 350 and 400 volts, respectively, plus two 20-A Darlington, types MJ10008 and MJ10009, rated at 450 and 500 volts.

Motorola also has a new FM stereo demodulator IC which is fabricated using the latest in I^2L , Ion Implant, and Bandgap technologies. Designated type MC1309, the device requires no inductors and very few other external components. A single potentiometer sets initial subcarrier vco frequency in the PLL demodulator, while an external load resistor choice enables the unit to be inserted as a unity gain element in the FM receiver's audio path, and a LED driver output is provided to indicate stereo operation. For operation on 4.5 to 16 volts, the MC1309 is supplied in a standard 16-pin DIP.

National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051) has developed a family of negative three-terminal adjustable voltage regulators. Designated the LM137 series, the monolithic devices complement the LM117 series of positive three-terminal regulators. With outputs adjustable from -1.2 to -37 volts using only two external resistors, the units have integral thermal regulation and a current rating of 1.5 A. Other features of the series are a high ripple rejection of 75 dB and an rms output noise of a mere 0.003% of the output voltage up to 10 kHz. The LM137 devices are in TO-3, TO-5, TO-220 and TO-202 packages. ◇

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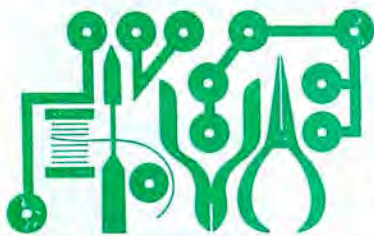
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Experimenter's Corner

By Forrest M. Mims

THE VOLTAGE MULTIPLIER

THIS MONTH, we're going to look at the diode-capacitor voltage multiplier, an extremely simple but very useful power-supply circuit. The diode-capacitor voltage multiplier allows the user to obtain a larger dc voltage than that available from his battery or transformer/rectifier supply. In ac circuits, this voltage multiplication is readily accomplished by transformers, so you can consider the voltage multiplier as a solid-state, dc step-up transformer with very limited current regulation capability.

These networks have found many applications in semiconductor electronics. They are commonly used in digital wrist-watches to derive required operating voltages from a single mercury cell. Voltage multipliers are also employed to obtain the relatively high voltages needed for powering neon glow lamps, electro-fluorescent displays and semiconductor lasers. Heavily insulated voltage multipliers are frequently found in the high-voltage sections of color television receivers and infrared-to-visible light conversion systems.

Although there are several basic voltage multiplier designs, they are all based on the principle of charging and discharging capacitors with the help of steering diodes. Let's look at a few representative circuits. All inputs are ac.

Typical Voltage Multipliers. Figure 1 is the schematic diagram of the traditional voltage doubler. In operation, an ac voltage is applied across the input terminals. During the negative half-cycle of the input signal (BP2 positive with respect to BP1), C2 charges to the peak

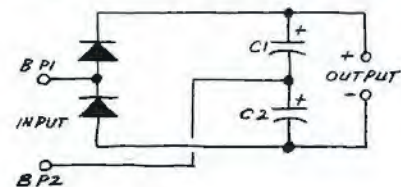


Fig. 1. Traditional diode-capacitor voltage multiplier.

value of the input voltage. During the positive half-cycle, C1 charges up to the peak value of the input voltage. Since C1 and C2 are in series, the output voltage is double the peak input voltage if the output is lightly loaded. Therefore, the capacitors must be rated to withstand the peak value of the input voltage and the diodes twice that value.

Figure 2 shows two other ways to make a voltage doubler. The cascade doubler (A) isn't as efficient or as well-regulated as either the traditional or bridge doubler, but it can easily be expanded to many stages. (Component voltage ratings are given in parentheses.) It's possible to obtain outputs of many thousands of volts from multi-stage cascade voltage multipliers. Figure 3 shows both a full-wave voltage tripler (A) and quadrupler (B).

You can duplicate any of the circuits in Figs. 1 through 3 using ordinary silicon rectifiers and suitably rated capacitors.

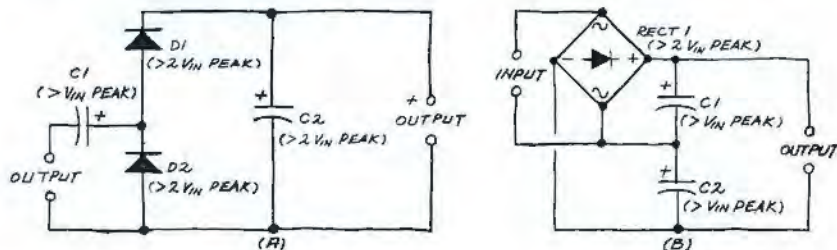


Fig. 2. Two different ways to make a voltage doubler.

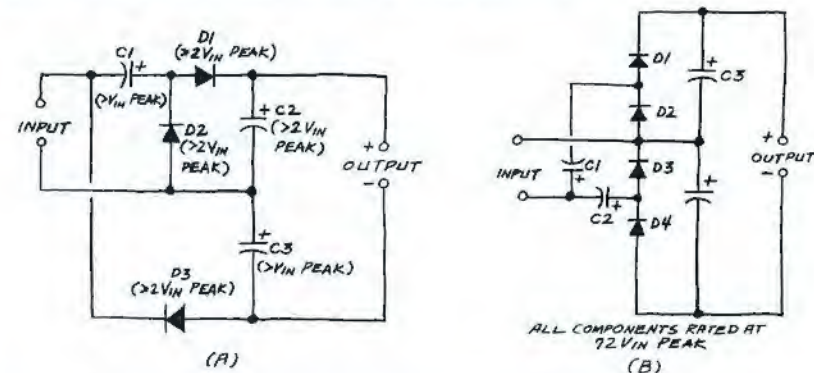


Fig. 3. Full-wave voltage tripler and quadrupler circuits.

Switching diodes (IN914 or IN4148) work fine in low-voltage applications. Rectifiers in the IN4000 series are a good choice for circuits with higher working voltages. Here are the voltage ratings for these rectifiers: IN4001, 50 volts; IN4002, 100 volts; IN4003, 200 volts; IN4004, 400 volts; IN4005, 600 volts; IN4006, 800 volts; IN4007, 1000 volts. Be sure to observe the polarities of diodes and electrolytic capacitors.

A Word of Caution. The sample voltage multiplier circuits that follow produce relatively low voltages. Voltage multipliers, however, can easily produce very high output voltages. If you decide to experiment with high-voltage multipliers, use caution and always make sure the capacitor chain is fully discharged before touching any circuit nodes. The capacitors in an unloaded voltage multiplier chain can retain a dangerous charge for hours after the power supply has been turned off.

Op-Amp Voltage Multiplier. It's very easy to generate square waves with an operational amplifier, so an op-amp oscillator makes an ideal input for a voltage multiplier. Figure 4 shows one possible circuit.

Virtually any op amp will work as a square-wave generator, but I've selected the RCA CA3078, a micropower op amp that will operate with power-supply voltages as low as ± 0.75 volt. With the component values shown in Fig. 4, the

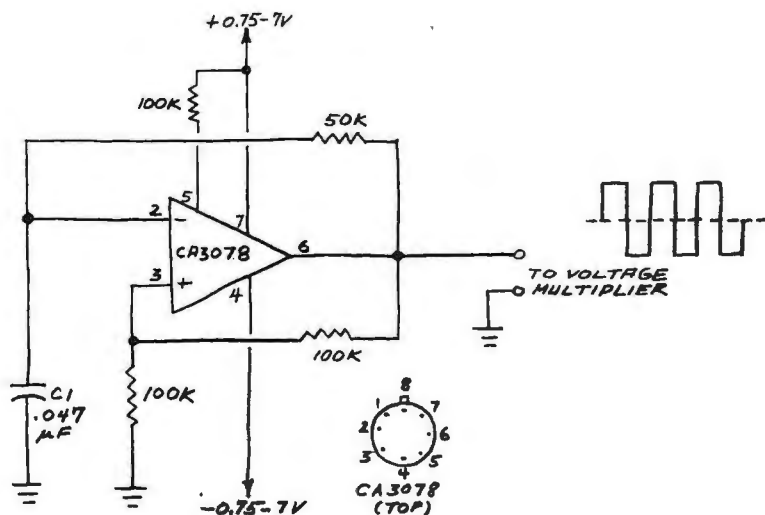


Fig. 4. Micropower op-amp oscillator circuit.

oscillator produces square pulses approximately four milliseconds wide at a frequency of 144 Hz. Increasing the value of $C1$ will increase the pulse width and reduce the oscillation frequency.

You can use the basic op-amp square-wave generator as an ac source for any voltage multiplier circuit. Figure 5 shows the results for a ten-stage cascade multiplier. Don't use a supply voltage greater than ± 7 volts if you use a CA3078 as the square-wave generator. For higher output voltages, add more multiplier stages or an op amp such as the 741 that will accept a higher supply voltage.

CMOS Voltage Multiplier. It's easy to build CMOS oscillator circuits that provide a square-wave output. Figure 6 shows one way to connect a voltage doubler to a typical CMOS oscillator comprising a clock followed by a 4013 D flip-flop. The clock is an astable multivibrator made from two of the four NAND gates in a 4011 integrated circuit. The flip-flop is operated as a toggle by feeding the not-Q output back to the D input.

Note that only half of each IC is used in this circuit. Because unterminated CMOS inputs can bias the gates into the linear operating region, it is essential to connect all unused inputs to either V_{DD} (the positive supply) or V_{SS} (ground). If your circuitry suddenly stops operating and one of the IC's becomes very hot, chances are you've left one or more inputs floating!

The voltage doubler shown in Fig. 6 works quite well. With the capacitor values given and a power supply of 6 volts, the flip-flop toggles at a frequency of 170 Hz and the doubler generates 11.3 volts.

Don't hesitate to experiment with the CMOS multiplier circuit. You can easily

produce more than 100 volts by powering the CMOS clock with a 12-volt supply and connecting the flip-flop to a ten-stage voltage multiplier like the one shown in Fig. 5. That's more than enough voltage for a neon glow lamp and a 100,000-ohm series resistor between the positive output terminal of the multiplier and V_{SS} (ground). (Take care—the high voltage can easily zap one or both of the CMOS chips.)

Further Reading. The Motorola "Silicon Rectifier Handbook" (1966) has an excellent chapter on voltage multipliers (Chapter 6). Radio Shack's "Semiconductor Projects, Volume 1" (1975) has a chapter that describes an op-amp pulse generator that powers a ten-stage cascade voltage multiplier. This circuit is capable of producing a 140-volt output when the op amp is powered by a 35-volt supply. ◇

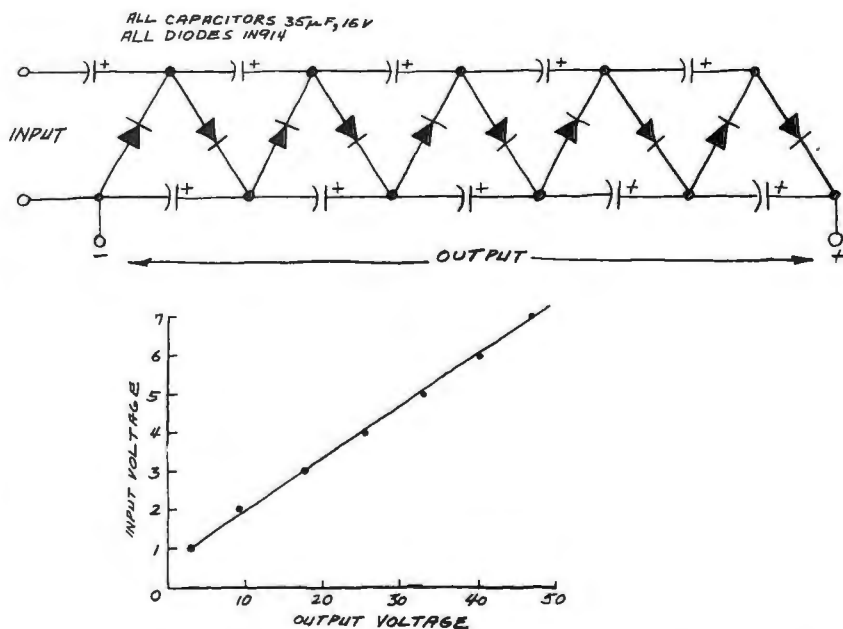


Fig. 5. Performance of op-amp oscillator and ten-stage multiplier.

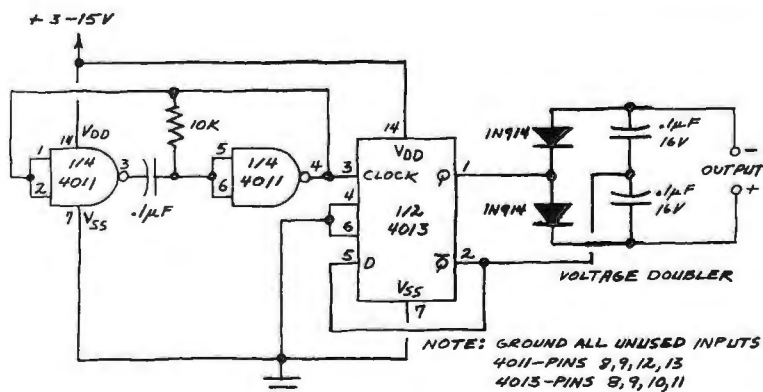


Fig. 6. CMOS oscillator and voltage doubler.



Product Test Reports

TRAM MODEL D62 AM/SSB MOBILE CB TRANSCEIVER

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THE Tram Model D62 CB transceiver is a 40-channel phase-locked loop (PLL) frequency-synthesized AM/SSB mobile rig. A special feature is an Anti-Theft Snap-Brak, an instantaneous quick-release mobile mounting bracket.

Other features include: LED numeric channel display; r-f, audio, and microphone gain controls; switchable automatic noise limiter (anl) and noise blanker (NB) combination; squelch and clarifier controls; SWR indicator; illuminated S/r-f/SWR meter; transmit-on indicator; automatic level or modulation control (alc or amc); PA facility; external-speaker jacks; detachable dynamic microphone; electronic voltage regulation for critical circuits; AM/LSB/USB mode switch; operation from a nominal 13.8-volt negative- or positive-ground dc source; and line filter and reverse-polarity protection.

The transceiver measures 10 3/4"D x 6 15/16" W x 2 3/8" H (27.3 x 17.6 x 6 cm). Suggested retail price is \$450.

Technical Description. The receiver section employs a single-conversion design, with its i-f at 7.8 MHz. AM and SSB selectivity are obtained with a crystal-lattice filter. A dual-gate FET r-f input amplifier provides high sensitivity with very good signal-handling capabilities against overloads.

The local heterodyning signal at the mixer is obtained from the PLL's FET voltage-controlled oscillator (the vco), whose output signal frequency is at the high side of the CB signal (CB signal plus 7.8 MHz). There are actually two in-

dividual vco's, one of which is used for AM and USB and the other for LSB. (The frequencies for each channel differ by approximately 3000 Hz so that the signal is in proper relationship to the i-f filter for the related transmission mode.)

Three i-f stages follow the filter, after which either a diode envelope detector and a series-gate anl are provided for AM or a transistorized product detector is used for SSB. The receiver's entire audio system is contained in a single IC. The power-output section of this IC doubles as the transmitter AM modulator.

Built into the receiver section is an amplified squelch setup. The noise blanker is arranged so that it is switched in and out simultaneously with the AM anl. The circuit data for the noise blanker was not given; the only indication that one is included is on the schematic diagram, with a note that it is incorporated into a single IC. The noise-blanker system picks up the noise pulses from the r-f amplifier and processes them for disabling the output of the mixer for the duration of each pulse.

The standard reference signal for the PLL system is derived from a 5120-kHz crystal oscillator. The output signal frequency from the vco is also divided to provide the comparison signal. As usual, both signals go to a phase comparator, where an error voltage is generated for correcting the vco's frequency. Red LED displays for the channel numbers are activated by decoder drivers.

On transmit, the 7802.5-kHz bfo signal goes to the balanced modulator for SSB and then to the filter and a balanced mixer, where the difference-mixture with the output of the vco produces the on-channel signal. The AM carrier is similarly generated at this mixer. The remainder of the transmitter's lineup consists of two r-f amplifiers, a driver stage, and a power amplifier operated in class C for AM and linearly for SSB.

On AM, a speech amplifier is inserted

ahead of the IC in the receiver that is used to modulate the transmitter, while on SSB two additional audio preamplifiers feed the balanced modulator. An automatic level control (alc) system is included for both AM and SSB to maintain high modulation without introducing adverse overmodulation.

A multielement output network in the power amplifier stage matches to 50-ohm lines and attenuates spurious responses. This network is also switched in on receive, where it provides improved image rejection and minimizes receiver radiation from the antenna terminals at frequencies above 28 MHz. Radiation from the case in the receiver section is additionally minimized with complete shielding and external-lead bypass capacitors. Antenna switching is performed with a relay, which also initiates other changeover functions.

Laboratory Measurements. On our test bench, the receiver's sensitivity measured 0.5 μ V on AM with 30% modulation at 1000 Hz and at least 0.15 μ V on SSB for 10 dB (S + N)/N. A slight divergence from these figures occurred on different channels. The squelch threshold range was 0.5 to 2500 μ V. The agc held the audio output to within 10 dB with an 80-dB r-f change at 1 to 10,000 μ V. The S meter registered S9 with a nominal 50- μ V signal, but meter peaking did not exactly coincide with maximum audio output.

The image, i-f, and other unwanted spurious-signal rejection were an unusually good 85, 85, and 75 dB minimum, respectively. On the other hand, a 1- μ V internal "tweet" appeared on SSB when the clarifier control was set to one end of its extremes. Adjacent-channel rejection and desensitization was a minimum of 65 dB. The unwanted-sideband rejection at 1000 Hz was 60 dB.

The 6-dB audio response on AM was 325 to 4000 Hz, while on SSB, it was 700 to 4700 Hz. The maximum sine-wave output on receive and PA was 3 watts at the onset of clipping with 1.1% THD at 1000 Hz and 1.7% THD at 400 Hz, both into 8 ohms.

Operating the transceiver from a nominal 13.8-volt dc power source, the output power of the carrier measured 4.25 to 4.5 watts, depending on the temperature. Tone modulation went to 90% at microphone input levels 16 dB greater than required for 50% modulation. The THD at 1000 Hz was 6% (6.5% at 500 Hz). Adjacent-channel splatter under these conditions was 50 dB down at

1000 Hz and 45 to 50 dB at 2500 Hz. With voice operation at maximum microphone gain, the modulation tended to slightly exceed 100% on both negative and positive peaks. Nevertheless, the splatter was 50 to 60 dB down. The overall 6-dB audio response of the transmitter was 700 to 2800 Hz on AM. It peaked at +3 dB at 1350 Hz (600 Hz was down 10 dB).

On SSB, the output power measured 12 watts PEP, with both tone and voice. A tendency toward flattopping was observed at maximum mike levels. However, third-order distortion products were 28 dB below PEP (22 dB below two equal-level tones). Carrier suppression was 45 dB. On LSB, the unwanted-sideband suppression at 1000 Hz was 45 dB, and on USB, it was 50 dB. (While still using a single 1000-Hz tone in the USB mode, a 35-dB down spur appeared at ± 3000 Hz. Beyond an 800-to-1200-Hz tone input, these spurs disappeared. In any event, we observed no deterioration in on-the-air signal quality. The overall 6-dB audio response on SSB was nominally 300 to 1350 Hz. The frequency tolerance of the transmitter held to within 0.0015% on all channels

at 65° to 85° F (18° to 29° C) ambient temperatures.

User Comment. The Anti-Theft Snap-Brak featured with this transceiver does not in itself prevent theft. What it does is allow the transceiver to be quickly and easily removed from its bracket without having to manipulate the usual holding knobs. This permits convenient removal of the rig for hidden storage elsewhere when the vehicle is left unattended, which is still the best insurance against theft. Removal is also simplified with a quick-disconnect plug at the power cable, although the antenna cable still requires unscrewing the connector.

During bench tests with an impulse-noise generator, the noise blanker/anl system performed well with noise pulses up to 100 dB above 1 μ V/MHz bandwidth, except at the 50-dB level, where its effectiveness was reduced. In on-the-road tests, we obtained good NB/anl performance on AM. Here, the audio gain of the receiver diminished to reduce weak signals by 6 to 8 dB. The end result of this was an improved S/N ratio.

The effectiveness in reducing noise pulses was not as noticeable on SSB,

which is inherently less noisy than AM.

On AM, the audio receiving quality was full and clear. As can be seen from our SSB response figures, the quality on SSB was somewhat thinner than on AM, apparently due to the high low-frequency cutoff point. However, the resulting crispness produced excellent intelligibility. Adjacent-channel rejection and freedom from overload made reception more interference-free than is usually the case in the presence of properly operated strong signals.

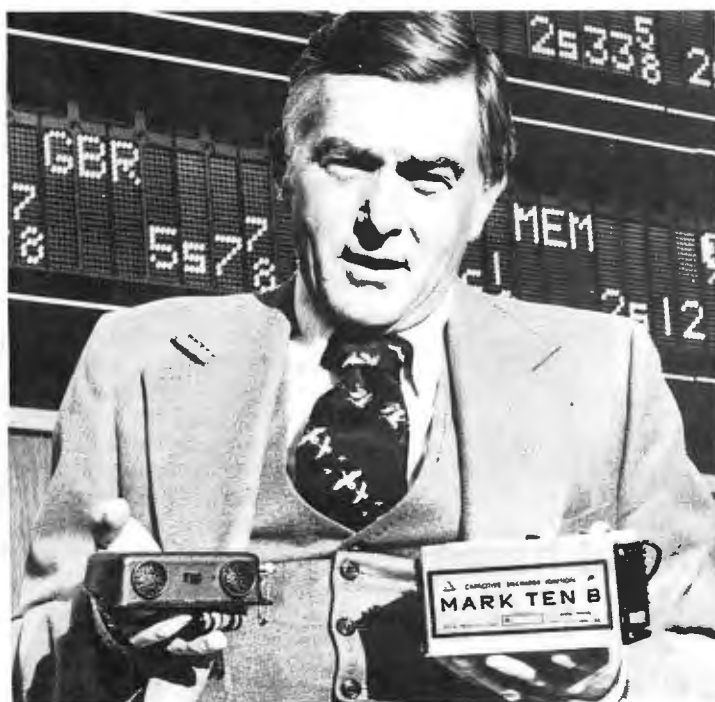
The audio quality on transmit in the AM mode was a bit thinner than usual. On SSB, however, it produced high intelligibility. SSB transmitting quality sounded lower pitched, but still provided excellent readability.

Although occasional overmodulation was experienced on both AM and SSB, no adverse effects were noted during our on-the-air tests.

In sum, this is a fine all-around transceiver. It provides excellent AM performance, while giving the operator all the advantages of SSB communication, a mode of communication to which more and more CB'ers are turning.

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Amateur Radio

GETTING IT TOGETHER AS A NOVICE

By Karl T. Thurber, Jr., W8FX

ONE BRIGHT summer day in 1954, I found in the mailbox a small rectangular envelope from the FCC containing a Novice Class ham license. Station KN2IKZ was now authorized to go on the air. Receiving the license was a particular thrill for me, then a 12-year-old SWL. I had failed the Novice code exam on the first try—in those days, exams were given on FCC premises and a passing score was by no means assured.

Once the thrill of actually holding a valid "ham" license had passed, I, like any newly licensed amateur, had to face the serious challenge of getting on the air and making the first contact. A Phil-

more 2-tube, 25-watt rig using a 6V6 crystal oscillator and 5Y3 rectifier (remember them?) got KN2IKZ going on 40 meters. Also used were a Hallicrafters S-40B all-wave receiver and a 60-foot "random wire" antenna. Not exactly a dream station, it did the job for several months until I got my General ticket and a then-modern Johnson Viking II and Hallicrafters SX-96 replaced their more humble predecessors.

The thrill is still experienced by today's newly licensed Novices, but the equipment today is different—and better! With the exception of those who tackle a Heath receiver kit, practically no one builds his or her own receiver any-

more. The technical sophistication of modern receivers, incorporating such features as frequency synthesis, multiple conversion and i-f filtering, make construction and check-out a very difficult task. Relatively few hams, Novice or otherwise, build their own transmitters, though it certainly can be done by the more enterprising and technically oriented. Transmitter construction, particularly for CW (Morse code) gear, is not as demanding, but is a much greater task than it was in 1954. This is due to the simple fact that unless you're working with a pre-packaged kit, obtaining all the parts needed is now a formidable task. The best bet for most Novices is to buy either ready-made gear or a kit, limiting initial construction projects to various accessories.

In the old days (actually, up to mid-1976, when the FCC raised the Novice power limit and allowed the use of vfo's), most Novices set their sights on a low-power, crystal-controlled ("rock-bound") transmitter such as the



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Heathkit DX-series (35,40,60, etc.) and an SWL-type receiver such as one of the old National, Hallicrafters, or Hammarlund models. The relaxation of the Novice operating restrictions has shed an entirely new light on the situation. Now, those who can afford it initially buy equipment suitable for General and higher-class operation. A compromise route is to purchase as good a receiver as possible, and to keep the first transmitter simple. The idea is to hold on to the receiver for some time but to sell the transmitter upon attaining the General or Advanced Class license, applying the proceeds toward the purchase of a CW/SSB transmitter or transceiver.

The first-class entry to ham radio, is simply to buy the future station transceiver or transmitter/receiver combination at the outset. There is much to be said for this approach—the more sophisticated gear works very well on CW, usually with full or partial break-in, and is

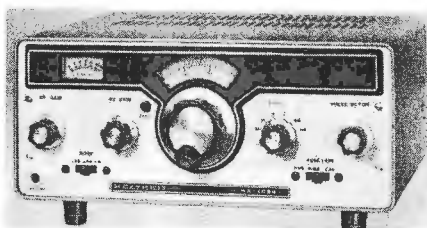
capable of running from 180 watts to 1000 watts on CW and SSB. These rigs usually cover 80 through 10 meters, with some covering 160 as well. This avoids the problem of disposing of the "starter" station but assumes that the Novice license *will* be upgraded. The approach represents considerable investment however, and may spur the newcomer to upgrade his license from a financial standpoint, if nothing else!

Transceivers Vs. Separates.

Which is better—a transceiver or separate transmitter and receiver? That's not an easy question to answer. Overall price levels are often the same, and no one rig will suit everyone's operating tastes. Amateur transceivers, like their CB counterparts, make efficient use of stages which perform dual receive and transmit-type functions. They tend to be compact and often can be placed in the car for mobile operation, and then taken out for portable use in a motel or vacation retreat. Some of the new solid-state units have built-in 12-volt dc and 117-volt ac power supplies. That means everything is in one package except mike, key, and antenna!

On the negative side, transceivers *do* have their limitations, so the very best-equipped stations do not normally use them. Without an external vfo, one cannot transmit and receive on different frequencies. Although in most QSO's both hams are on the same frequency, some DX stations will not listen for calls on their own frequency. Instead, they ask stations to call them, for example, "10 kHz up" or "10 down" to avoid a pile-up on the DX station's transmitting frequency. The use of an external vfo alleviates *this problem*, but then we're back to two separate units and added cost. Another problem is that serious CW work is difficult with some transceivers because of exact zero-beating (getting exactly on the other fellow's frequency) problems, lack of full break-in keying, and restricted frequency coverage.

For those willing to put the time and energy into building a transceiver kit, a good bet probably was the Heathkit HW-16 transceiver. Unfortunately, it has been discontinued. The Heath Company does sell the HW-8, a 3-watt QRP (flea-power) package that, notwithstanding Heath's reputation for quality and the success some operators have had working at very low power levels, probably will not do the job on today's super-crowded bands, with many Novices running the full 250-watt limit. Successfully




Heath MR-1680 SSB/CW receiver kit covers 80-10 meters.

operating a "QRP station" takes a great deal of skill and clear frequencies. The HW-16 can be found in dealers' used-

equipment showrooms and at hamfests. The same is true for its transmitter counterparts such as the DX-35, DX-40, and DX-60. There is now a dearth of new low-to-medium power, CW-only rigs suitable for use by the beginner. (Used amateur gear is, incidentally, usually very well maintained and cared for by its owner and should definitely be considered for purchase.)

On the brighter side, Ten-Tec has introduced its new "Century 21" CW transceiver. The rig is solid-state and runs 70 watts, has vfo control, covers 80



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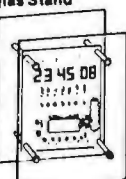
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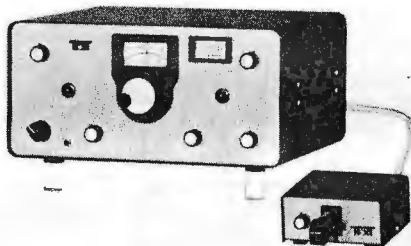
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through 10 meters and sports a number of accessories of interest to the Novice or CW buff, including an inexpensive keyer and plug-in crystal calibrator. Price is approximately \$300, about the most you would want to invest in a CW-only 'starter' transceiver.

As for receivers, there is frankly little available to the Novice who wants to build a kit, but good, ready-made equipment is available from Drake, Collins, Kenwood and Yaesu. However, the Heath HR-1680 solid-state SSB/CW receiver kit is a good one, and at \$200



Ten-Tec Century/21 Novice rig.

represents an excellent value. It can provide several years of service before

most hams will see the need to upgrade. Even then, it could find a place in the shack as an auxiliary receiver. Heath's instructions, in case you don't know, are usually as foolproof as they can possibly be. The kit features no-instrument alignment, four printed circuit boards, an open chassis layout, and a wiring harness to simplify assembly. If you do go the separate receiver/transmitter route, buy the very *best* receiver you can afford at the outset to avoid having to dispose of a cheaper unit that will probably outgrow its usefulness when a higher-class license is obtained.

Many of the older (but not ancient) good-quality receivers will also be suitable. Among these are the SX-71, SX-76, HQ-180, NC-183D, NC-303, SX-111, HQ-110, SX-190, HA-350, and the HRO series. Unless you're a technical whiz, stay away from World War II surplus receivers—they just won't make it today. Exceptions to this rule are the Collins war-surplus R-390 and 51-J1.

Rapidly becoming a Novice "standard" is the relatively inexpensive (\$340) Heath HW-101 5-band transceiver which runs 170 watts on CW or 180 on SSB. Because phone provisions are built-in, the rig is perfectly suitable for use after your General ticket has arrived. It features semi-break-in keying. The VOX circuitry is keyed by a built-in CW sidetone which also allows you to monitor the transmitted CW signal. About the only accessories needed to get the HW-101 on the air are an antenna key, ac power supply, and (not absolutely necessary but nice) the 400-cycle CW accessory crystal filter to separate closely spaced signals. *Very similar* to the HW-101 but not a kit, is the Tempo One, an import distributed by Henry Radio. It carries many of the features of higher-priced gear, but costs a shade under \$500. Both can be purchased as used equipment.

R.L. Drake's TR-4CW SSB/CW transceiver is also a good bet for the beginner, and won't be obsoleted once the General license is obtained. Designed especially with the Novice/Technician in mind, it covers 80 through 10 meters with up to 300 watts PEP (peak envelope power) SSB input and 200 watts on CW. That's more than enough power to drive a 2-kW PEP linear amplifier should the occasion arise. Some of the features which make it especially attractive to the Novice are the built-in 500-kHz CW filter, 1-kHz dial calibration, 100-kHz crystal calibrator, wide-range agc and shifted-carrier CW operation.

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Incidentally, Drake equipment is essentially tube-type. Tube-type rigs are considered "old-fashioned" by many but are somewhat easier to repair by the nontechnical ham. Available as optional accessories are an external vfo for split-frequency work, matching speaker and choice of power supplies (dc or ac).

The Drake Transceiver is in a different price class than the simpler Heath equipment mentioned earlier—the TR-4CW without accessories retails at about \$650. That's quite an investment for a beginner! However, older, used Drake equipment, such as the TR-3 and TR-4 would do a good job for the beginner with a more modest investment. Also, if you're lucky enough to find one in good condition, the venerable Johnson Viking "Ranger" or "Navigator" of late 50's vintage make beautiful Novice transmitters, having vfo control and medium power levels (75 watts for the Ranger and 40 for the Navigator). E.F. Johnson long ago gave up on the Amateur market, going heavily into CB, but its equipment is still occasionally seen at hamfests and in the used equipment sections of dealers' showrooms.

Comparable to the Drake line are the Tempo 2020, the Yaesu FT-101E series and the Kenwood TS-520. All offer "custom" features which must be evaluated in terms of the user's interest in the hobby and his needs. The best bet, of course, is to thoroughly investigate the market (including the *used* equipment market) before buying *anything*. Seek advice from local hams and obtain comparative literature from various manufacturers. The period between taking the Novice exam and receiving the license is an excellent time to evaluate specifications, decide on a transceiver vs. receiver/transceiver combination, and actually set up the station in preparation for the big day.

In Closing. No matter what your final decision is as to what equipment will comprise your first ham station, choose carefully and keep the future in mind. A correct first choice can mean the difference between enjoying ham radio and losing interest. Keep in mind that cheap equipment is not necessarily the best value for your dollar. Before plunking down that hard-earned cash, ask a ham who uses the equipment you're considering for his *honest* opinion of his gear. Finally, visit one of the big hamfests or conventions where the major manufacturers exhibit their wares so you can make side-by-side comparisons. ◇

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Computer Bits

COMPUTERS TO AID HANDICAPPED

By Leslie Solomon

LAST MARCH, we attended the second annual West Coast Computer Faire and heard eight papers discussing different ways computer enthusiasts can help handicapped people.

This is ample evidence that making home computers to aid the handicapped is an excellent project for computer clubs. It would certainly be more gratifying than Star Trek or creating more computer games. And modestly priced equipment—voice interfaces, modems, controllers, etc.—for this purpose is at hand. If you would like to contribute your talents to this much-needed computer-to-human interfacing, contact Computers for the Handicapped, c/o Warren Dunning, 5939 Woodbine Ave., Phila-

delphia, PA 19131. You will find it challenging and exciting.

PET Doings. The PET computer, like many of its predecessors is starting to spawn a "cottage industry" of bus plug-in devices.

HUH Electronic Music Productions, BOX 259, Fairfax, CA 94930 (Tel: 415-457-7598), is now making several PET add-ons. Among these is the PET-100, that allows the PET to use conventional S-100 boards. This approach uses a cable-connected board that plugs into an S-100 motherboard (that also has a power supply), with the other end of the cable connected to the PET expansion connector. Two versions

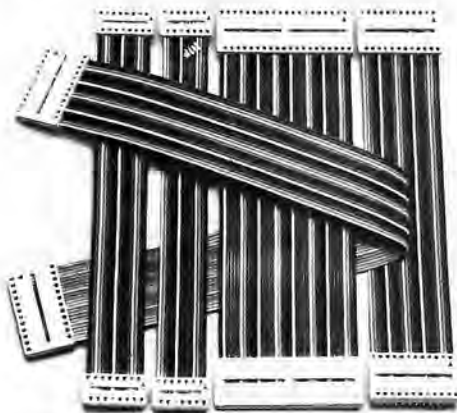
are available: mode-1 emulates most S-100 functions except RDY so it has fast memory and no wait states; and mode-2 allows read and write wait states. Kit is \$199.95, assembled it is \$279.95

Another add-on is PETSQUEAK (\$19.95) which automatically "beeps" when a file header is found or written, and when a program is loaded or saved. It may also be used as a beeper under program control. PET-TUNE-YA (\$29.95) is an 8-bit D/A converter that can be used as a music generator or as a DAC for graphics or control. The PET Video Buffer (\$19.95) is a video combiner that allows the use of conventional large-screen video monitors for classroom display.

S-100 Bus Things. It seems like almost every day something new comes along for the ubiquitous S-100 bus, and here is one more:

Objective Design Inc., POB 20325, Tallahassee, FL 32304 (Tel: 904-224-5545), has released its Programmable Character Generator board for \$149.95 kit and \$195 assembled/tested. This S-100 plug-in works with any of the

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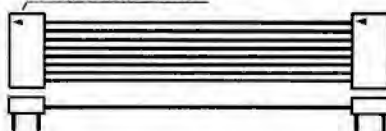
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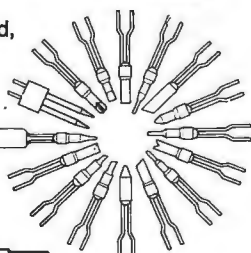
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Motorola 9×7 matrix character generators such as used in the VDM-1, SOL, Poly VTI, SSM Video Board, etc. To use this new board, the character generator ROM is removed from the existing system, and plugged into a socket on the PCG. The PCG, in turn, is plugged into the now-empty character generator socket. Under software control, data in the 2K of RAM on the PCG can replace some or all of the characters in the old ROM. Such features as APL characters, special math or scientific symbols, foreign alphabets, italics, or other forms of emphasis, or even music symbols can be created. Programmable characters may be used to create graphics up to 512 × 256. The PCG achieves its high resolution without external memory or DMA activity.

Breadboarding. Probably the best way to try out a new circuit is to breadboard it, preferably using solderless sockets. This way, you can try all sorts of hardware "tricks" without causing any heat damage. In line with this, AP Products Inc., Box 110, 72 Corwin Drive, Painsville, OH 44077 (Tel: 216-354-2102), has released three POWER-ACE Circuit Evaluators said to have twice the component capacity of other solderless breadboards. All three models offer 256 × 5 tie-point terminals, and 16 × 25 tie-point busses, fused power supply, and a ground plane.

POWERACE 101 (\$84.95) features a 5-to-15-volt, 600-mA dc supply having excellent characteristics, and a 5%, 0-15-volt meter. POWERACE 102 (\$114.95) has a fixed 5-volt, 1-ampere supply, four slide switches with logic-0 or logic-1 outputs, and two debounced momentary switches delivering positive or negative output pulses. In addition, this model also has four LED's, a debounced pushbutton with positive or negative pulse output, and a clock generator from 1 Hz to 100 kHz output. POWERACE 103 (\$124.95) is a beefed-up version of the 102, with the addition of a ±15-volt, 250-mA supply, and a 0-15-volt meter.

EPROM Erasure. There have been many articles on programming EPROM's, but erasure has been left up to the user. One way to erase EPROM's is by using the UVS-11E Low-Cost EPROM Erasing Lamp (\$59.50) from Ultra-Violet Products Inc., 5100 Walnut Grove Ave., San Gabriel, CA 91778 (Tel: 213-285-3123). It is available from many electronics suppliers and comput-

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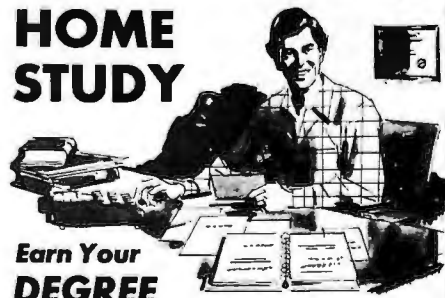
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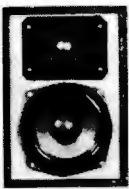
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er stores. The UVS-11E holds up to four chips in a conductive foam base, and supports the chips at 1" from the UV lamp. Up to four chips can be erased in 20 minutes. The holding tray absorbs all UV while transmitting visible light. (The UV lamp will not operate unless seated within the holding tray. When the lamp is lifted from the tray, it goes off.)

Cabinets. Its one thing to build a new keyboard, a TVT, or a complete system, but locating a decent cabinet is something else.

If packaging has been a problem, contact Custom Electronics Industries, 609 Route 109, West Babylon, NY 11704 (Tel: 516-884-2121). This firm makes a variety of high-impact plastic enclosures for a variety of computer items. Prices range from \$39.95 for a TVT cabinet and up depending on size. Cabinets are available painted or unpainted.

New I/O Port. According to Vector Graphics Inc., 790 Hampshire Rd., A-B, Westlake Village, CA 91361 (Tel: 805-497-6853), its Bit Streamer I/O S-100 board (\$155 kit, \$195 assembled), available through most computer stores, combines two parallel, and one serial I/O port with an 8251 programmable UART. One parallel port can also be used as a keyboard input port. Without changes to the pre-jumpered options, the board can also operate as an RS-232 serial port.

Ham/Computer Terminal. Xitex Corp., POB 20887, Dallas, TX 75220 (Tel: 214-620-2993), is marketing its SCT-100 low-cost S-100 plug-in video terminal. Using the Mostek 3870, the board produces 64 characters and 16 lines of 5x8 dot matrix characters and has a 128-character set including upper and lower case, numerics, Greek, common symbols, and special graphic symbols. The board can use either ASCII (110/300 baud) or baudot (45/72 baud). Full cursor control is provided. Both 20- and 60-mA serial loops are provided, as is RS-232. All loops are opto-isolated.

Having both ASCII and baudot, the board can be used for ham FSK as well as computer applications. Three versions are available: SCT-100A is assembled and tested for \$185; SCT-100K is a kit for \$155; and SCT-100P is a partial kit that includes the 3870, character generator ROM, crystal, pc board, and complete documentation at a price of \$85. The documentation package (SCT-100D) is available for \$3.



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Micro "APL" for 8080. 8k EMPL is a micro APL for 8080 based computers, using ASCII-character adaptations of the APL symbols and operators. EMPL has numeric and character vectors (one-dimensional arrays), user-defined functions, 22 primitive functions, 9 system commands, and many other special operators and characters. Typical operators

and commands include: logical and arithmetic functions, catenation, string, literal-text, branch, absolute, random, and many others. The program itself resides in the first 5.6k bytes of memory, but requires a minimum of 8k total RAM. Double-precision integer arithmetic, with a range of ± 32767 is used. EMPL is available on Tarbell cassette for \$10 (NJ residents add 5% tax), including user's manual, from Erik T. Mueller, Britten House, Roosevelt, NJ 08555; and from Tarbell Electronics, 20620 S. Leapwood Ave., Suite P, Carson, CA 90746, for \$15 (California residents add 6% tax). Also available for \$20 on paper tape, North Star disk, CUTS cassette or MITS cassette from supplier.

6800 Math Package. A math package with 12-digit accuracy up to the value 549,755,813,887, and with 11-digit accuracy for higher values, is available for the SWTPC 6800 computer. Calculations are floating-point, with 5-byte mantissas plus 1-byte exponent, a 25% saving in storage over BASIC, with higher accuracy. The package also supports Fortran-type formatting of floating-point and integer specifications in both read and write. The package includes binary-to-ASCII conversion routines. Updates will be sent to all original purchasers for the cost of postage and disk or tape. If the customer supplies his own disk or tape, the charge will be \$1.00. Cost of the math package is \$107.50 in Smoke Signal Broadcasting disk, or \$103.00 on KC-standard, 300-baud cassette. Write: AAA Chicago Computer Center, 3007½ W. Waveland Ave., Chicago, IL 60618, or participating dealers.

6502 Resident Assembler and Editor. The ASM65 resident assembler and Mini-Editor for 6502 systems are designed to work together, and can produce object paper tapes as well as listings. Both are available in KIM or TIM format; addressing for the ASM65 is 1000-1FA6 (TIM) or 2000-2FBD (KIM); for the mini-editor it's 2600-297F and 3600-3997F for the TIM and KIM versions respectively. The ASM65 on hex dump or paper tape is \$13; the manual is \$5, and a cross-assembly listing is \$28. Prices for the Mini-Editor are \$4.00 for the hex dump or binary paper tape, \$2.50 for the manual, and \$7.50 for the listing. All prices are post-paid, first class. A catalog of other programs is \$1.00. Write: The 6502 Program Exchange, 2920 Moana, Reno, NV 89509.

8080 Multitasking Scheduler. MTS/80 is a real-time multitasking scheduler for Intel SBC 80/10 single-board computers. It features relocatable binary libraries, including I/O drivers and system utilities; source code, and manuals. On MDS-800-compatible floppy discs, MTS/80 is \$995. If purchased separately, the user's manual is \$25, and the System Generation Procedure and I/O Driver Implementation Manuals are \$10 each. Write: Resource Control, 2701 152nd Ave. NE, Redmond, WA 98052.

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Published by Howard W. Sams & Co., Inc., 4300 West 62nd St., Indianapolis, IN 46268. 287 pages. \$9.95 soft cover.

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by Edwin Schlossberg
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Divided into games for one, two, three or more players, this book presents 50 games of mathematics and strategy, many of which will sharpen players' arithmetic abilities. All games are thoroughly explained, with examples of typical game runs that can be used with simple "four-banger" calculators.

Published by William Morrow & Company, Inc., 105 Madison Ave., New York, NY 10016. 203 pages. \$6.95 hard cover, \$3.95 soft cover.

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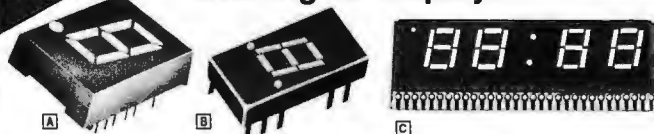
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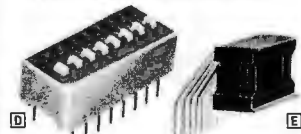
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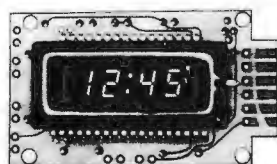
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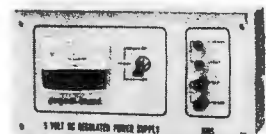
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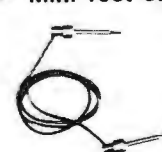
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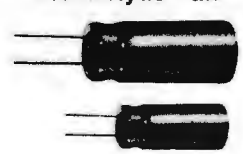
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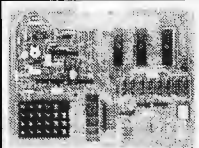
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47	6/\$1.00	5/\$1.00	4/\$1.00	4/\$1.00	3/\$1.00
100	5/\$1.00	5/\$1.00	4/\$1.00	4/\$1.25	3/\$1.00
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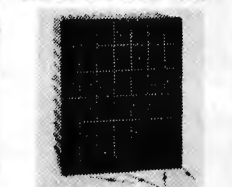
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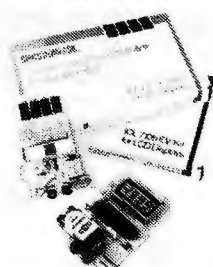
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	SN7417	.29	.30	SN7486	1.95	1.96	SN74166	1.25	1.26			
	SN7418	.29	.30	SN7487	1.95	1.96	SN74167	1.25	1.26			
	SN7419	.29	.30	SN7488	1.95	1.96	SN74168	1.25	1.26			
	SN7420	.29	.30	SN7489	.69	.70	SN74169	1.25	1.26			
	SN7421	.29	.30	SN7490	.69	.70	SN74170	1.49	1.50			
	SN7422	.29	.30	SN7491	.69	.70	SN74171	1.49	1.50			
	SN7423	.29	.30	SN7492	.69	.70	SN74172	1.49	1.50			
	SN7424	.29	.30	SN7493	.49	.50	SN74173	1.49	1.50			
	SN7425	.29	.30	SN7494	.49	.50	SN74174	1.49	1.50			
	SN7426	.29	.30	SN7495	.49	.50	SN74175	.99	1.00			
	SN7427	.29	.30	SN7496	.49	.50	SN74176	.99	1.00			
	SN7428	.29	.30	SN7497	.49	.50	SN74177	.99	1.00			
	SN7429	.29	.30	SN7498	.49	.50	SN74178	.99	1.00			
	SN7430	.29	.30	SN7499	.49	.50	SN74179	.99	1.00			
	SN7431	.29	.30	SN7500	.49	.50	SN74180	.49	.50			
	SN7432	.29	.30				SN74181	.49	.50			
	SN7433	.29	.30				SN74182	.49	.50			
	SN7434	.29	.30				SN74183	.49	.50			
	SN7435	.29	.30				SN74184	.49	.50			
	SN7436	.29	.30				SN74185	.49	.50			
	SN7437	.29	.30				SN74186	.49	.50			
	SN7438	.29	.30				SN74187	.49	.50			
	SN7439	.29	.30				SN74188	.49	.50			
	SN7440	.29	.30				SN74189	.49	.50			
	SN7441	.29	.30				SN74190	.49	.50			
	SN7442	.29	.30				SN74191	.49	.50			
	SN7443	.29	.30				SN74192	.49	.50			
	SN7444	.29	.30				SN74193	.49	.50			
	SN7445	.29	.30				SN74194	.49	.50			
	SN7446	.29	.30				SN74195	.49	.50			
	SN7447	.29	.30				SN74196	.49	.50			
	SN7448	.29	.30				SN74197	.49	.50			
	SN7449	.29	.30				SN74198	.49	.50			
	SN7450	.29	.30				SN74199	.49	.50			
	SN7451	.29	.30				SN74200	.49	.50			
	SN7452	.29	.30				SN74201	.49	.50			
	SN7453	.29	.30				SN74202	.49	.50			
	SN7454	.29	.30				SN74203	.49	.50			
	SN7455	.29	.30				SN74204	.49	.50			
	SN7456	.29	.30				SN74205	.49	.50			
	SN7457	.29	.30				SN74206	.49	.50			
	SN7458	.29	.30				SN74207	.49	.50			
	SN7459	.29	.30				SN74208	.49	.50			
	SN7460	.29	.30				SN74209	.49	.50			
	SN7461	.29	.30				SN74210	.49	.50			
	SN7462	.29	.30				SN74211	.49	.50			
	SN7463	.29	.30				SN74212	.49	.50			
	SN7464	.29	.30				SN74213	.49	.50			

POP-AMPS AT "CENT-CIBLE" PRICES

Case code: T=TO-220 Power Tube; V=Mini dip; K=TO-3; H=TO-5; N=DIP.

Type	Each	2 for	Type	Each	2 for	Type	Each	2 for
LM300H	\$4.99	\$5.00	LM370H-H	1.29	1.30	LM741V-H	.29	.30
LM301H-V	.45	.46	LM370H	1.79	1.80	LM1310	.99	1.00
LM308H-V	.79	.80	LM376V	.29	.30	LM1312	1.99	2.00
LM309H	.79	.80	LM377H	2.25	2.26	LM1414	.79	.80
LM311H-V	.79	.80	LM381H	1.69	1.70	LM1458V	.69	.70
LM318V	1.29	1.30	LM381H	1.49	1.50	LM1800H	.99	1.00
LM320H-S, 12, 15	1.29	1.30	LM382H-H	.29	.30	LM3808H	.69	.70
LM320K-15	1.29	1.30	LM385V	.79	.80	LM3900H	.99	1.00
LM320T-6, 5	1.29	1.30	LM385V	.79	.80	LM3909H	1.75	1.76
LM322H	1.19	1.20	LM385V	1.00	1.01	LM4195	1.95	1.96
LM324H	1.19	1.20	LM385V	.99	1.00	LM4250	1.19	1.20
LM339H	1.09	1.10	LM385V	.49	.50	LM75451	.39	.40
LM340K-S, 6, 8	1.29	1.30	LM703H	.29	.30	LM75453	.39	.40
LM340T-S, 6, 8	1.29	1.30	LM703H	.29	.30	LM75491	.79	.80
LM340T-S, 6, 8, 12, 15, 18, 24	1.29	1.30	LM703H	.29	.30	LM75492	.79	.80
LM350H	.59	.60	LM733H	.79	.80	LM75494	.59	.60
			LM739H	.89	.90			

YOU GET 120-DAY MONEY BACK GUARANTEE

10 AMP - POWER TABS! SCRS! TRIACS! QUADRACS!

Order by Cat. No. and voltage!

PRV	Sale	2 for
50	\$.55	\$.56
100	.89	.90
200	1.19	1.20
400	1.59	1.60

#E1448 - TRIACS GE1730 - SCR #E1590 - QUADRACS

HI-POWER STUD RECTIFIERS

Cat. No. 6E3567 - 150 amp	Each	2 for	Cat. No. 6E87UG65 - 250 amp	Each	2 for
V. 50	\$ 2.95	2 for \$ 2.96	V. 50	\$ 4.95	2 for \$ 4.96
100	3.95	2 for 3.96	100	6.50	2 for 6.51
200	4.95	2 for 4.96	200	7.50	2 for 7.51
400	7.50	2 for 7.51	400	8.50	2 for 8.51
600	9.00	2 for 9.01	600	10.50	2 for 10.51
800	10.50	2 for 10.51	800	13.50	2 for 13.51
1000	12.51	2 for 12.52	1000	14.50	2 for 14.51

Order by Cat. No. & Voltage

25 AMP BRIDGE RECTIFIERS

Order by Cat. No. 6E2273 & voltage

V	Each	1c SALE
50	\$1.95	2 for \$1.96
100	1.49	2 for 1.50
200	1.69	2 for 1.70
400	1.99	2 for 2.00
600	2.25	2 for 2.26
800	2.51	2 for 2.52

25 AMP POWER STUD SCRS, TRIACS

Order by Cat. No. 6E14A147 (SCRs) Cat. No. 6E60B86A (TRIACS)

V	Each	1c SALE
50	\$.95	2 for \$.96
100	1.25	2 for 1.26
200	1.95	2 for 1.96
400	2.50	2 for 2.51
600	3.95	2 for 3.96

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Cat. No.	Type No.	PIV	Price	1c MORE!
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6E2378	1N4002	100	10 for .75	20 for .86
6E2379	1N4003	200	10 for .85	20 for .96
6E2380	1N4004	400	10 for .95	20 for 1.06
6E2381	1N4005	600	10 for 1.29	20 for 1.40
6E2382	1N4006	800	10 for 1.39	20 for 1.40
6E2383	1N4007	1000	10 for 1.49	20 for 1.50

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PRV	10 for	20 for	50 for
50V	\$.59	\$.60	\$.61
100V	.79	.80	.81
200V	.99	1.00	1.01
400V	1.19	1.20	1.21
600V	1.39	1.40	1.41
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MICRO MINI TOGGLE SWITCHES!

3 Amps, 125 VAC contacts, with chrome handles, complete with mounting hardware.

Cat. No.	Type	Price
6E3936	SPDT	\$1.29
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6E4037	DPDT	1.45
6E5087	DPDT*	1.55

LYTIC KLINIC

Order by Cat. No. 6E3269 & value

UF	V	Style	Sale
10	15	P.C.	10 for \$1.00
50	15	P.C.	8 for 1.00
15	25	P.C.	8 for 1.00
50	25	P.C.	8 for 1.00
10	50	P.C.	10 for 1.00
20	15	P.C.	10 for 1.00

6 AMP CARTWHEEL RECTIFIERS

Cat. 6E3584

V	Each	1c SALE
50	\$.36	2 for \$.37
100	.45	2 for .46
200	.61	2 for .62
400	.79	2 for .80
600	1.11	2 for 1.12
800	1.19	2 for 1.20
1000	1.39	2 for 1.40

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Order by Cat. No.

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Order by Cat. No. 6E5210 & voltage & wattage!

1 Watt	5 Watt	1c SALE
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8.2V	5 for 1.10	10 for 1.01
9.1V	5 for 1.10	10 for 1.01
11.1V	5 for 1.10	10 for 1.01
15.1V	5 for 1.10	10 for 1.01

5 WATTS

Sale	1c SALE
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6.3V	3 for 1.6 for 1

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2758	26.00
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2112-1	3.00	3.25	3.25
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2112-3	11.00	10.00	9.25
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2147	37.50		
3106	2.50	2.35	2.00
3107	3.85	3.70	3.25
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TMS4045	11.00	10.00	9.25
5101	8.30	7.40	7.25
74C09	3.25	3.05	2.85
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	1.65	1.45	1.30

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\$100.00 KIT
BARE BOARD \$30.00

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N8T96	1.35
N8T97	1.35
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with 1K RAM		
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with 1K RAM		
MR 16T 16K users 2708i		\$99.00
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E-PROM	KIT	\$117.00
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TU-1

Convert T.V. set to
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250ns ASSEMBLED & TESTED	\$189.95
450ns ASSEMBLED & TESTED	\$149.75
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450ns KIT	\$125.00
BARE BOARD	25.00
6800 ADAPTER to S-100 System	
KIT	\$12.95

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450ns ASSEMBLED & TESTED	\$380.00
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450ns KIT	\$675.00

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On board Refresh power is provided with no wait states or cycle stealing required	
*BVDC 400MA DC, *18VDC 400MA DC and 18VDC 30MA DC	
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8K (375ns) KIT	\$151.00
16K (375ns) KIT	\$259.00
24K (375ns) KIT	\$367.00
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KIT	\$95.00
22 slot	\$149.95
ASSEMBLED & TESTED	

THE PROM SETTER

WRITE & READ	
EPROM	
1702A - 2708 - 2716	
5204 - 6834	
* Plug directly into your ALTAIR IMSAI Computer Includes Main Module Board and External EPROM Socket Unit	
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* Programming is accomplished by the Computer	
* Just read in the Program to be Written into the EPROM into your Processor and into the Computer to use the program	
* Use Socket Unit to Read EPROM's	
* Software included	
* No external power supplies. Your setup is the only one	
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* Manual included	
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ASSEMBLED	\$375.00

KIM-1

ASSEMBLED & TESTED	\$245.00
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for KIM-1	
8K RAM (21L02)	
8K EPROM	
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JADE Z80

—with PROVISIONS for
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only \$17.95 with trade
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To trade, you must give us your 2MHz Z80 chip
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8224-4 clock driver 20 pf. capacitor

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CT 100

S100 BUS COMPATIBLE

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Microprocessors need the power that a real time clock
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COMPU/TIME does not have to be initialized every time
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Powerful software included for

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1 MHz Crystal Oscillator

Two independent interrupts

One interrupt uses 16 bit counter in

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Both software programmable

Board can be selected by 128 device

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Complete documentation includes soft

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Enhancement to users of
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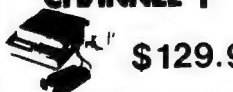
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0811 - 1st-1st Shooting Gallery 0815 - Spacewar! (2 players) 0819 - Drag strip (1 or 2 players)

0812 - Desert Fox Shooting Gallery 0818 - Magic Numbers (computer logic) 0820 - Maze (2 players)

0822 - Baseball (2 players)

D-SUB CONNECTORS

NO. PINS	PART NO.	PRICE	COVER PRICE
9	DE-9P	1.49	1.25
9	DE-9S	2.15	
15	DA-15P	2.11	1.50
15	DA-15S	3.10	
25	DB-25P	3.00	1.50
25	DB-25S	4.00	
37	DE-37P	4.14	2.00
37	DE-37S	6.00	
50	DD-50P	5.40	2.25
50	DD-50S	8.00	

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NO. PINS	TYPE	PRICE
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30	DUAL 15 PIN	GOLD 1.95
44	DUAL 22 PIN	GOLD 2.50
44	DUAL 22 PIN	GOLD 4.95
80	DUAL 40 PIN	GOLD 5.00
80	DUAL 40 PIN	GOLD (IMSAI/ALTAIR) 4.25
100	DUAL 50 PIN	GOLD (IMSAI/ALTAIR) 4.95
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MM5314	6 Digit, 12 or 24 Hour, 50 or 60 Hz	4.95
MM5316	4 Digit, Alarm, 1 PPS Output	6.95
MM5318	Video Clock Chip, For Use With MM5311-18 (\$9.95)	9.95
CT7801	6 Digit, Calendar, Alarm, 12 or 24 Hour	5.95

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1-24	25-99	100-999	1k
10	34	32	26
14	34	33	29
16	34	34	30
18	70	80	54
20	80	75	67
22	80	80	72
24	80	80	72
26	80	80	71
28	140	125	100
30	140	140	120

IC SOCKETS

1-24	25-99	100-999	1k & Up
(8)	15	14	12
(14)	25	20	16
(18)	28	27	26
(22)	34	33	30
(26)	36	35	34
(28)	40	42	36
(40)	60	58	49

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7400 18	7443 20	74100 1.75	74187 1.80
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7402 20	7445 100	74102 45	74184 1.50
7403 20	7446 95	74103 80	74185 1.50
7404 20	7447 95	74104 200	74186 1.50
7405 20	7448 95	74105 120	74187 1.50
7406 35	7449 20	74106 55	74170 2.00
7407 35	7450 20	74107 55	74172 9.75
7408 25	7451 20	74108 55	74173 1.50
7409 25	7452 20	74109 55	74174 1.10
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7411 25	7454 20	74111 55	74176 1.20
7412 40	7455 20	74112 55	74177 9.00
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7426 35	7469 55	74126 1.10	74193 1.10
7427 35	7470 40	74127 1.10	74194 1.20
7428 40	7471 40	74128 1.10	74195 1.20
7429 40	7472 40	74129 1.10	74196 1.20
7430 40	7473 40	74130 1.10	74197 1.20
7431 40	7474 40	74131 1.10	74198 1.20
7432 30	7475 70	74132 1.10	74199 1.20
7433 30	7476 40	74133 1.10	74200 1.20
7434 30	7477 40	74134 1.10	74201 1.20
7435 30	7478 40	74135 1.10	74202 1.20
7436 30	7479 40	74136 1.10	74203 1.20
7437 30	7480 89	74137 1.10	74204 1.20
7438 30	7481 89	74138 1.10	74205 1.20
7439 30	7482 89	74139 1.10	74206 1.20
7440 30	7483 89	74140 1.10	74207 1.20
7441 30	7484 89	74141 1.10	74208 1.20
7442 30	7485 89	74142 1.10	74209 1.20
7443 30	7486 89	74143 1.10	74210 1.20
7444 30	7487 89	74144 1.10	74211 1.20
7445 30	7488 89	74145 1.10	74212 1.20
7446 30	7489 89	74146 1.10	74213 1.20
7447 30	7490 89	74147 1.10	74214 1.20
7448 30	7491 89	74148 1.10	74215 1.20
7449 30	7492 89	74149 1.10	74216 1.20
7450 30	7493 89	74150 1.10	74217 1.20
7451 30	7494 89	74151 1.10	74218 1.20
7452 30	7495 89	74152 1.10	74219 1.20
7453 30	7496 89	74153 1.10	74220 1.20
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7455 30		74155 1.10	74222 1.20

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4003 25	4053 1.10	4520 1.65	MM74C126N 1.38
4004 25	4054 3.25	4521 3.25	MM74C127N 1.38
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4010 48	4060 35	4527 1.75	MM74C133N 1.38
4011 25	4061 35	4528 1.75	MM74C134N 1.38
4012 25	4062 35	4529 1.75	MM74C135N 1.38
4013 60	4063 35	4530 1.75	MM74C136N 1.38
4014 1.25	4064 35	4531 1.75	MM74C137N 1.38
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4016 59	4066 35	4533 1.75	MM74C139N 1.38
4017 1.25	4067 35	4534 1.75	MM74C140N 1.38
4018 1.25	4068 35	4535 1.75	MM74C141N 1.38
4019 70	4069 35	4536 1.75	MM74C142N 1.38
4020 1.25	4070 35	4537 1.75	MM74C143N 1.38
4021 1.25	4071 35	4538 1.75	MM74C144N 1.38
4022 1.25	4072 35	4539 1.75	MM74C145N 1.38
4023 35	4073 35	4540 1.75	MM74C146N 1.38
4024 1.00	4074 35	4541 1.75	MM74C147N 1.38
4025 35	4075 35	4542 1.75	MM74C148N 1.38
4026 2.25	4076 35	4543 1.75	MM74C149N 1.38
4027 80	4077 35	4544 1.75	MM74C150N 1.38
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4029 1.50	4079 35	4546 1.75	MM74C152N 1.38
4030 60	4080 35	4547 1.75	MM74C153N 1.38
4031 1.50	4081 35	4548 1.75	MM74C154N 1.38
4032 1.50	4082 35	4549 1.75	MM74C155N 1.38
4033 2.00	4083 35	4550 1.75	MM74C156N 1.38
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4035 1.50	4085 35	4552 1.75	MM74C158N 1.38
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4039 1.50	4089 35	4556 1.75	MM74C162N 1.38
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4044 1.25	4094 35	4561 1.75	MM74C167N 1.38
4045 1.25	4095 35	4562 1.75	MM74C168N 1.38
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74LS00

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74LS04 29	74LS05 29	74LS06 29	74LS07 29
74LS08 29	74LS09 29	74LS10 29	74LS11 29
74LS12 29	74LS13 29	74LS14 29	74LS15 29
74LS16 29	74LS17 29	74LS18 29	74LS19 29
74LS20 29	74LS21 29	74LS22 29	74LS23 29
74LS24 29	74LS25 29	74LS26 29	74LS27 29
74LS28 29	74LS29 29	74LS30 29	74LS31 29
74LS32 29	74LS33 29	74LS34 29	74LS35 29
74LS36 29	74LS37 29	74LS38 29	74LS39 29
74LS40 29	74LS41 29	74LS42 29	74LS43 29
74LS44 29	74LS45 29	74LS46 29	74LS47 29
74LS48 29	74LS49 29	74LS50 29	74LS51 29
74LS52 29	74LS53 29	74LS54 29	74LS55 29
74LS56 29	74LS57 29	74LS58 29	74LS59 29
74LS60 29	74LS61 29	74LS62 29	74LS63 29
74LS64 29	74LS65 29	74LS66 29	74LS67 29
74LS68 29	74LS69 29	74LS70 29	74LS71 29
74LS72 29	74LS73 29	74LS74 29	74LS75 29
74LS76 29	74LS77 29	74LS78 29	74LS79 29
74LS80 29	74LS81 29	74LS82 29	74LS83 29
74LS84 29	74LS85 29	74LS86 29	74LS87 29
74LS88 29	74LS89 29	74LS90 29	74LS91 29
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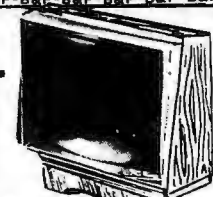
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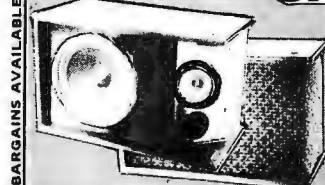
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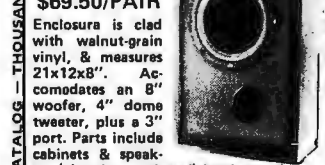
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7404-13 7434-21 7404-43 7401-120	
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7406-13 7436-21 7406-43 7401-85	
7407-13 7437-21 7407-43 7401-85	
7408-13 7438-21 7408-43 7401-85	
7409-13 7439-21 7409-43 7401-85	
7410-13 7440-21 7410-43 7401-85	
7411-13 7441-21 7411-43 7401-85	
7412-13 7442-21 7412-43 7401-85	
7413-13 7443-21 7413-43 7401-85	
7414-13 7444-21 7414-43 7401-85	
7415-13 7445-21 7415-43 7401-85	
7416-13 7446-21 7416-43 7401-85	
7417-13 7447-21 7417-43 7401-85	
7418-13 7448-21 7418-43 7401-85	
7419-13 7449-21 7419-43 7401-85	
7420-13 7450-21 7420-43 7401-85	
7421-13 7451-21 7421-43 7401-85	
7422-13 7452-21 7422-43 7401-85	
7423-13 7453-21 7423-43 7401-85	
7424-13 7454-21 7424-43 7401-85	
7425-13 7455-21 7425-43 7401-85	
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74LS00-21	74LS126-47	LM 101-75
74LS02-21	74LS132-80	LM 301/748-39
74LS03-21	74LS136-38	LM 317-75
74LS04-21	74LS138-70	LM 311-75
74LS05-28	74LS139-70	LM 318-76
74LS08-21	74LS151-70	LM 319-95
74LS10-21	74LS155-70	LM 324-105
74LS11-21	74LS156-70	LM 339-110
74LS12-44	74LS157-72	LM 358-140
74LS15-25	74LS160-85	LM 370-125
74LS20-24	74LS161-85	LM 377-750
74LS21-26	74LS162-85	LM 380-95
74LS22-26	74LS163-85	LM 381-125
74LS23-32	74LS164-85	LM 382-125
74LS24-32	74LS165-85	LM 383-250
74LS25-32	74LS170-188	LM 553-850
74LS26-32	74LS171-110	LM 555-25
74LS27-32	74LS174-100	LM 556-85
74LS28-32	74LS175-80	NE540L-225
74LS29-32	74LS180-85	NE540L-225
74LS30-32	74LS181-85	NE540L-225
74LS31-32	74LS182-85	NE540L-225
74LS32-32	74LS183-85	NE540L-225
74LS33-32	74LS184-85	NE540L-225
74LS34-32	74LS185-85	NE540L-225
74LS35-32	74LS186-85	NE540L-225
74LS36-32	74LS187-85	NE540L-225
74LS37-32	74LS188-85	NE540L-225
74LS38-32	74LS189-85	NE540L-225
74LS39-32	74LS190-85	NE540L-225
74LS40-32	74LS191-85	NE540L-225
74LS41-32	74LS192-85	NE540L-225
74LS42-32	74LS193-85	NE540L-225
74LS43-32	74LS194-85	NE540L-225
74LS44-32	74LS195-85	NE540L-225
74LS45-32	74LS196-85	NE540L-225
74LS46-32	74LS197-85	NE540L-225
74LS47-32	74LS198-85	NE540L-225
74LS48-32	74LS199-85	NE540L-225
74LS49-32	74LS200-85	NE540L-225
74LS50-32	74LS201-85	NE540L-225
74LS51-32	74LS202-85	NE540L-225
74LS52-32	74LS203-85	NE540L-225
74LS53-32	74LS204-85	NE540L-225
74LS54-32	74LS205-85	NE540L-225
74LS55-32	74LS206-85	NE540L-225
74LS56-32	74LS207-85	NE540L-225
74LS57-32	74LS208-85	NE540L-225
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74LS60-32	74LS211-85	NE540L-225
74LS61-32	74LS212-85	NE540L-225
74LS62-32	74LS213-85	NE540L-225
74LS63-32	74LS214-85	NE540L-225
74LS64-32	74LS215-85	NE540L-225
74LS65-32	74LS216-85	NE540L-225
74LS66-32	74LS217-85	NE540L-225
74LS67-32	74LS218-85	NE540L-225
74LS68-32	74LS219-85	NE540L-225
74LS69-32	74LS220-85	NE540L-225
74LS70-32	74LS221-85	NE540L-225
74LS71-32	74LS222-85	NE540L-225
74LS72-32	74LS223-85	NE540L-225
74LS73-32	74LS224-85	NE540L-225
74LS74-32	74LS225-85	NE540L-225
74LS75-32	74LS226-85	NE540L-225
74LS76-32	74LS227-85	NE540L-225
74LS77-32	74LS228-85	NE540L-225
74LS78-32	74LS229-85	NE540L-225
74LS79-32	74LS230-85	NE540L-225
74LS80-32	74LS231-85	NE540L-225
74LS81-32	74LS232-85	NE540L-225
74LS82-32	74LS233-85	NE540L-225
74LS83-32	74LS234-85	NE540L-225
74LS84-32	74LS235-85	NE540L-225
74LS85-32	74LS236-85	NE540L-225
74LS86-32	74LS237-85	NE540L-225
74LS87-32	74LS238-85	NE540L-225
74LS88-32	74LS239-85	NE540L-225
74LS89-32	74LS240-85	NE540L-225
74LS90-32	74LS241-85	NE540L-225
74LS91-32	74LS242-85	NE540L-225
74LS92-32	74LS243-85	NE540L-225
74LS93-32	74LS244-85	NE540L-225
74LS94-32	74LS245-85	NE540L-225
74LS95-32	74LS246-85	NE540L-225
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100	40	70	1.30	40	1.20
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uPC6030*		Precision Monolithic, Inc., DAC-01	10.00	8.05	7.38

*Pin Connection and Electrical Characteristics are completely compatible to original manufacturers.

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uPC301C	LM301AN	.39	.31	.29	.27
uPC1458C	LM1458N	.58	.46	.43	.39
uPC324C	LM324N	1.00	.74	.70	.65
uPC311C	LM311N	.75	.61	.56	.51
uPC339C	LM339N	.78	.59	.55	.50
uPC305C	LM376N	1.50	1.25	1.13	1.00

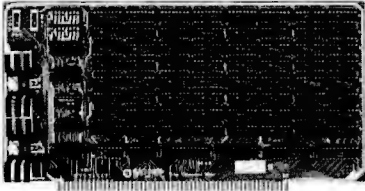
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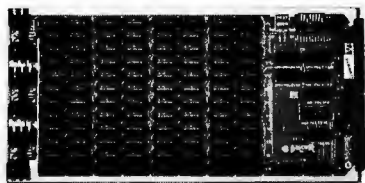
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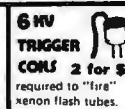
This battery operated device continuously emits bursts of intense light. Great safety device for bicycle riders, skiers, hikers, boaters & campers. Comes complete w/ all electronic parts, quality glass-epoxy P-C board & easy to understand instructions. Uses high-output xenon flash tube which flashes 2 times per second when batteries are fresh. Operates continuously for 12 hours on 2 alkaline "C" batteries. You need only to supply the batteries and, if desired, a battery holder & case.



C23207 \$6.95
(3 for \$18.00)



COMPLETE variable rate strobe light kit. Contains all parts including line cord, PC board and instructions. Operates on 117 VAC. \$7.50 each



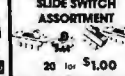
required to "fire" xenon flash tubes.



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WITH SPECS. \$1.25
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C23083 4 for \$1.00



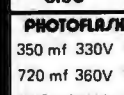
1POLE, 8 POSITION 79¢



SHUTTER CORD \$1.00

Electronic Flash Unit Guide no. 28 ASA 25.

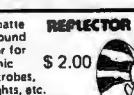
These were to be installed in cases but the final assembly was never completed. You get a complete working flash unit. Operates on 2 AA penlight batteries. You need only supply a shutter cord, battery holder & batteries, & if desired, some sort of case. Approx. overall size of circuit board, reflector & capacitor: 3" x 2 1/2" x 1 1/2".



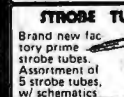
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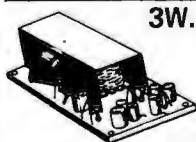
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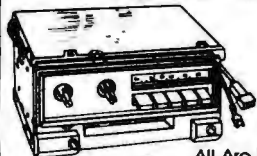
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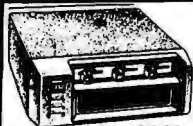
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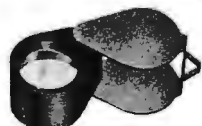


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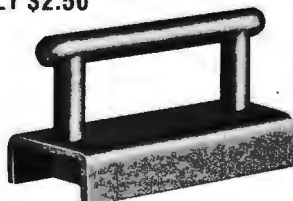
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Crescent Industries, Inc., portable wire recorder. Service manual or any repair information. Dr. F. T. Lee, Dept. of Physics, University of Rochester, Rochester, NY 14627.

Lafayette CAB transceiver tester model J 0788. **Sylvania** type 132 oscilloscope. Schematic and manuals. J. Douglas Sanfear, 5 Green Ave., Glen Falls, NY 12081.

Precision Radiation Instruments, Inc., Model 107B professional geiger counter. Schematic and operator/instruction manuals. Harold Timmons, 1819 Hazel St., Gridley, CA 95948.

Dumont 340 serial #4X72 oscilloscope. Need manual schematics or any information. Richard Gorton, Drawer B N-13, Patton, CA 92369.

Westinghouse RA/DA vintage radio. Schematic, parts or any information. J.A. Call, 1876 E. 2990 So., Salt Lake City, UT 84106.

Supreme model 333 tube tester, **Superior** model 450 tube tester. Schematic diagram, service manual or tube chart. M. Aaron, 3012 Center St., Oklahoma City, OK 73120.

Lafayette HE-30 communications receiver. Conversion schematic needed. A. Plamondon, 339 Edinburgh Dr., Ridge, NY 11961.

B&K TV Analyst model 1075. Operation manual and schematic. Ron Patton, Country Eats, Pk-9B, Pratt, KS 67124.

Paco model C-20 register capacitor bridge. Need power transformer or entire inoperative unit for parts. Robert Pilcher, Box 548, Jackson, NJ 08527.

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RCA AVQ-50 weather radio. Duplication manual, if original unavailable. Cecil K. Wells, Box 4-2889, Anchorage, AK 99509.

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Dura model Mach 10 electronic typewriter. Schematic. Paul Lennard, 3139 East Almond Ave., Orange, CA 92669.

Heathkit extended range 0-6 oscilloscope. Operation manual and schematic. Charles Van Dyke, 11231 Oak St., El Monte, CA 91731.

Harman-Kardon model 3-30 stereo receiver. Schematic and information on power transformer. Mike Welp, 1522 10th Ave. North, Ft. Dodge, IA 50501.

Waterman Products model S-15A pocket scope. Operation manual and any available information. Frank Sokolove, 3015 Graham Rd., Falls Church, VA 22042.

RCA WV-98A VTVM. Schematic. Paul Lombardi, 470 W. Fountain St., Providence, RI 02903.

Metrotec model TA-200 graphic stereo equalizer. Schematic. Duane Anderson, Rt. 2, Box 64, Leeds, ND 58346.

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ADVERTISERS INDEX

READER SERVICE NO.	ADVERTISER	PAGE NO.
1	A P Products Incorporated	110
2	Active Electronic Sales Corp	119
3	Anconra Corp	118
4	Audio Discount Warehouse	24
5	Audio-Technica U.S., Inc	12
6	B&F Enterprises	128
7	B&K Precision, Dynascan Corporation	6
8	Bearfinder, Inc	108
9	Byte	114
10	CRI Capitol Radio Engineering Institute	102, 103, 104, 105
11	Chaney Electronics	130
12	Cleveland Institute of Electronics, Inc	8, 9, 10, 11
13	Cobra, Product of Dynascan	SECOND COVER
14	Communications Electronics	112
15	Continental Specialties Corporation	40
16	Creative Computing Magazine	109
17	D R I	13
18	Delta Products, Inc	101
19	Digi-Key Corporation	117
20	Digital Group, The	91
21	Digital Research Corp	30
22	EICO	111
23	ESS	138, THIRD COVER
24	Edmund Scientific Corp	131
25	Electro-Voice, Inc	36
26	Electronic Distributors, Inc	129
27	Electronic Systems	134
28	Fordham Radio Supply	128
29	Fluke	17
30	Godbout Elecs., Bill	130
31	Grantham College of Engineering	111
32	Hazeltine Corporation	95
33	Heath Company	97
34	Hewlett-Packard	14, 15
35	IE Integrated Electronics	128
36	Illinois Audio	114
37	International Components Corp	132
38	J B L	3
39	JS&A National Sales Group	1
40	Jade Computer Products	126, 127
41	Jameco Electronics	124, 125
42	Lafayette Radio Electronics	FOURTH COVER
43	McIntosh Laboratory Inc	109
44	McKay Dymek Co	93
45	Micro Computer Mart	113
46	Motorola Semiconductor Products Inc	96
47	NRI Schools	18, 19, 20, 21
48	National Technical Schools	52, 53, 54, 55
49	Netronics R&D Ltd	51
50	New-Tone Electronics	120
51	New-Tone Electronics	138
52	OK Machine & Tool Corporation	5
53	Olson Electronics	131
54	Optoelectronics	107
55	PAIA Electronics, Inc	114
56	Page Digital Electronics	94
57	Poly Paks	123
58	Quest Electronics	133
59	Radio Hut	115
60	Radio Shack	23, 87, 116
61	Sansui Electronics Corp	27
62	Schober Organ Corp., The	106
63	Scientific Audio Electronics, Inc	29
64	Solid State Sales	129
65	Southwest Technical Products Corp	25
66	Speakerlab, Inc	112
67	Stanton Magnetics, Inc	31
68	Stereo Discounters	112
69	TK Enterprises	111
70	TAB Books	112
71	Technics by Panasonic	39
72	U.S. Pioneer Electronics	7
73	Wahl Clipper Corporation	111
74	CLASSIFIED ADVERTISING	135, 136, 137

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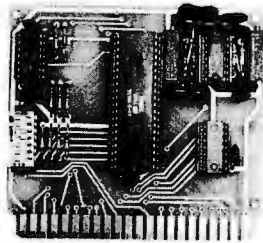
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7460N	74LS20N	25	LM340T-24	110	CMOS	7461	62.00
7461N	74LS20N	25	LM340T-24	110	CMOS	7462	63.00
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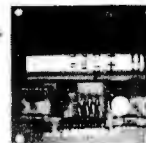
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Part no. 107

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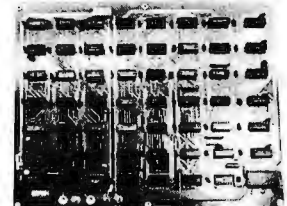
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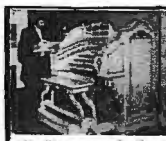
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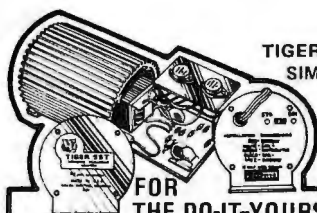
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The Heil achieves this virtually "instant acceleration"™ by *squeezing* air rather than *pushing* it. A simple experiment dramatically illustrates the superiority of the squeezing mo-

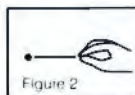
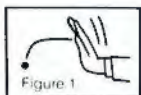


**Transar/atd, the world's
most accurate reproducer.**

tion. Imagine trying to "shot put" or *push* a light object like a cherry pit (air) with the palm of your hand (a speaker cone). It won't travel very far or fast (Fig. 1). Now put the pit between your thumb and forefinger and *squeeze* (Fig. 2). It squirts out at high velocity. The physics of the Heil are just this simple and brilliant.

Transar/atd, the first full range Heil air-motion sound system, uniting the Heil air-motion transformer with the new Heil low frequency driver, is an equally astounding breakthrough. Transar's technical brilliance can be explicated at great length, but not in a few paragraphs. However, we invite requests for ESS's

theoretical monograph "Transar: A Study in Genuis, A Study in Physics". But Transar is not the kind of product that stands or falls on theory. Its profound superiority is something one experiences with a sudden "shock of recognition". Treat yourself to the loudspeaker of the future. Experience Transar.



**Dr. Oskar Heil's cherry
pit illustration**

transar/atd

ESS inc. 9613 Oates Drive • Sacramento, Calif. 95827

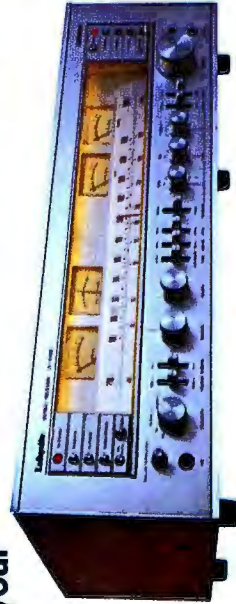


Your tuning band is like everything else in the city. Crowded. The LR-120DB helps you pick your way through the crowd.

In many cities, there are hundreds of stations crowded shoulder-to-shoulder across the tuning band. So moving across the band, you get hum, and hiss, and static.

The LR-120DB has adjustable FM muting, which allows you to mute out as much interference as you want, and zero in easily on your station.

The LR-120DB costs \$600. You can't get adjustable FM muting anywhere else for under \$900!



Adjustable FM muting may be the LR-120DB's biggest exclusive in its price range.

But it is by no means the only one.

The LR-120DB is the only receiver anywhere near this price level that offers you all of the following features in addition to the adjustable FM muting.

RESERVE POWER. One measure of a fine receiver (like a fine automobile) is pure power. The LR-120DB gives you 120 watts** per channel; more power than you'll ever need. The lesser power of lesser receivers can distort the signal just when you're enjoying the music most—but the LR-120DB has the power to capture even the most demanding passages with perfect fidelity... even at the highest listening levels.

BUILT-IN FM DOLBY.* You know what Dolby* does; you know why it's a virtual necessity in a fine FM receiver. During the critical passages when an oboe or a violin carries a delicate solo, the hissing of the signal can literally destroy the beauty of the sound. Dolby* lets you reduce such disruptive sounds to the vanishing point—and enjoy the music unimpeded. Nothing—not even your own receiver—should be allowed to hiss great music.

There is one more significant advantage to the built-in Dolby: * money. With more and more top-quality FM stations broadcasting in Dolby,* many receivers now offer a provision for adding a Dolby* decoder—at your expense. But the LR-120DB, with Dolby* built-in, lets you enjoy the highs (and escape the hissing) without spending extra for a decoder.

DUAL POWER METERS with adjustable range read-out, one for each channel. There are other receivers which offer this feature—but there are very few in this price range.

At the risk of repeating ourselves: the LR-120DB is the only receiver in its price range which offers all of these features. (For a complete list of features, write for a free brochure: Lafayette, 111 Jericho Turnpike, Syosset, N.Y. 11791.)

Lafayette will put a lot of pleasure in your ears—without a lot of worry on your mind.

Lafayette

Its sound stands out in the crowd.

*A trademark of Dolby Labs Inc.

**120 watts per channel, both channels driven into 8 ohms from 20 to 20,000 Hz. with no more than 0.09% THD.